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THE NATURAL HISTORY OF THE HAIRY-BACKED ANIMALCULES (CHÆTONOTIDÆ).

BY PHILIP HENRY GOSSE, F.R.S.

(*With Two Plates.*)

WHOEVER has been in the habit of collecting the floccose matter that accumulates around the submerged stems of aquatic plants, or the impalpable sediment that lies at the bottom of still pools and running ditches, and of examining the same in the live-boxes of his microscope, is aware how abundant and how various are the forms of life that are presented to his view. Creatures the most strange and the most incongruous—odd in their shapes, odd in their structure, odd in their manners, odd in their movements, swim, or rotate, or creep, or wriggle over the field of vision, till the little pellet of brown mud, no bigger than a grain of duck-shot, flattened out before him, proves a complete microcosm. Many such pellets will not have passed under the eye of the curious observer before he will pretty certainly have become familiar with a little creature of attractive appearance and lively manners, which forms the typical representative of a limited group of animals, whose family name I have set at the head of this article. Dr. Ehrenberg, of Berlin, named it the Bristle-fish (*Chætonotus*), both of which appellations allude to the long and stout bristles with which its back is beset in rows. Its movements are not so rapid as those of many animalcules, and therefore it affords a fair object for the young microscopist, while its form is so peculiar as to be easily recognized. When enclosed in an aquatic live-box, it is fond of crawling on the surface of the glass cover, whereby we distinctly see the ventral surface, as we see the lateral form when it creeps about the stems. The form, when seen vertically, is somewhat fish-like, with a thick, blunt, and rather triangular head, and a slight constriction or neck; a swelling body, terminating in two diverging points. The figure, when

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seen sidewise, reminds one of that of a ferret, the back being much arched (Plate i. Fig. 1). The whole body appears covered with hairs, which are set in rows; those on the front part are smaller and closer, those on the back larger and fewer. The fore-part, seen from beneath, presents an appearance of hatching or cross lines running diagonally, or else of dots set in quincunx, which I suppose are the bases of the hairs growing in such an arrangement. The internal structure is not usually discernible; for though the body is pellucid and colourless, and often lustrous from the refraction of the light, especially through the neck, the number of hairs which stud the surface prevent a clear sight of the interior. Two bands, which run down the belly, are understood to be bands of cilia. There is a certain nimbleness and sprightliness in the motions of this pretty animal as it crawls, frequently turning short on itself and changing its course (see Fig. 2), examining various objects, much like a caterpillar does, with apparent intelligence. I shall return to this species again for fuller details; but this general description will help the reader better to understand the group of which I propose to treat.

The form appears to have been recognized in the earliest records of microscopic observation; for Joblot, nearly a century and a half ago, described an animalcule, which was probably enough this very creature, under the title of "Poisson à tête tréflée." I say "probably," because an *approximation* to the general outline of such minute creatures was all that, with their very imperfect instruments, the early observers could accomplish. About sixty years later Müller, the great Danish zoologist, and the first who attempted to define and arrange the host of microscopic animalcules that were crowding upon observers, described under two names—*Cercaria podura* and *Trichoda larus*—what may have been two species of the same family, or one. The two specific names have, however, been adopted in modern nomenclature, as representing two distinct creatures, the latter being appropriated to the one I have described; though on what account he applied the name *larus*, which signifies *a gull*, to it, I cannot conjecture. Passing by other observers, who have recorded nothing more worthy of note concerning the form, than that they recognized it, we come to Ehrenberg, who, in his valuable papers in the Transactions of the Berlin Academy for 1831, and afterwards in his notable work *Die Infusionsthierchen*, determined the two genera, *Ichthydium* and *Chætonotus*, for the two species described by Müller, adopting his specific names, and added two more species to the latter genus.

The great Prussian zoologist included these creatures among the Rotifera, uniting with them in the same group two other

genera, which have no real affinity with them, his system of arrangement being artificial, and therefore, necessarily, in some cases, unnatural.*

M. Dujardin, in 1841, described another species, which he named *Ch. squammatus*, and rejecting Ehrenberg's arrangement, united the then known forms with others, with which they have no more affinity, and placed the heterogeneous group among the Infusory animalcules by the name of *Symmetrical Infusoria*. His ground for the change is thus expressed:—"The Ichthydina, according to M. Ehrenberg, ought to have a rotatory organ, simple, continuous, with an entire margin; but, in fact, the vibratile cilia of the ventral surface of the Chætonotes do not at all constitute a rotatory organ."†

Ten years later, the same zoologist described another form (Plate ii. Fig. 16) under the title of *Echinodera*,‡ apparently allied to the same group; to which, however, he now assigned a higher place, viz., intermediate between Crustacea and Vermes. He believes that this is "a type differing from the *Helminthes acanthocéphales*, the *Systolides* [Rotifera], the *Entomostraca Copepoda* [Cyclops, etc.] and the Sipuncles, yet at the same time offering points of resemblance to each of these. It is a sort of *Copepode* without feet, with the mouth of a *Sipunculus*, and the neck of an *Echinorhynchus*, and a muscular œsophagus like those of the *Systolides*, the *Tardigrades*, and the *Nematoid Helminthes*."

M. Perty§ and Herr Vogt‖ concur in the exclusion of the *Chætonotidæ* from the ROTIFERA; the former, however, has not ventured to assign them any definite position, while the latter associates them with the Planarioid worms (TURBELLARIA).

* It is the fashion to depreciate and decry Ehrenberg. I have no sympathy with those who, taking their stand upon the ground which he has cleared with incredible labour and genius, can assume airs of pity or contempt when they discern inconsistencies or defects in his system. Many years' study of the Rotifera has enabled me in some measure to appreciate the gigantic labours of the Prussian microscopist, and to compare them with those of his successors and critics. I take, for example, Dujardin's *Hist. des Infusoires*, and have no hesitation in asserting that this work does not manifest one-fourth part of the real actual acquaintance with the subjects treated, that is possessed by Ehrenberg's great work. Corrections and improvements in some points cannot fail to be pointed out by those who begin where the Prussian left off; and the advance of science, and the improvement of the microscope itself, have, of course, made antiquated and displaced many of his statements and conclusions; but, looking at microscopic zoology as it was when Ehrenberg took it up, and as it was when he laid it down, I think it not too much to say that he stands in the foremost ranks of the scientific army, side by side with such names as Aristotle, Linnæus, and Cuvier, and that his *Die Infusionsthierchen* is a monument to his fame, *ære perennius*, and such as few indeed have been able to erect.

† *Hist. des Infus.*, p. 569.

‡ *Annal. d. Sci. Nat.* 1851. The name is erroneously spelled "Ellimoderia" in the 4th Ed. of Pritchard's *Infusoria*, p. 380.

§ *Zur Kenntniss kleinster Lebens formen.*

‖ *Zoologische Briefe.*

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Dr. Max Schulze, describing yet another genus, *Turbanella* (Pl. ii. Fig. 15), in 1853,* took occasion to institute an elaborate examination of the structure of the whole group, augmented by all these discoveries. He considers that it does without doubt fall within the great circle of VERMES, though there is some difficulty in determining in which class to place it. Its union with the ROTIFERA he judges impossible: 1, because of the absence of the vibratory organs around the mouth, so characteristic of that class; 2, because muscles, nerves, and water-vessels—organs which are wanting in no true Rotifera—have not been found in this group; 3, because of the absence of a caudal extremity, furnished with articulated members; and 4, because of the peculiar cilia with which the ventral surface is clothed in the Chætonotes. *Turbanella* shows traces of a division into segments in the separation of the head from the rest of the body, in the ring of cilia which surrounds the head, and in the position of the almost regularly recurring lateral processes, and thus reminds us, in its ciliation and its obscure articulation, of several states of development of the true ANNELIDA. I may add, that the *Echinodera* of Dujardin, and my own curious genus, *Taphrocampa* (Figs. 17–19), presently to be described, carry this appearance of segmentation still further, and, *pro tanto*, strengthen the grounds of affinity with the ANNELIDA.

Dr. Schulze cites the analogy of certain Annelida, which possess, even in the adult condition, a ciliated skin. *Polyophthalmus* (Quatref.) has a ciliary head-veil, not unlike that of the Rotifera. The genus *Spio* is provided, according to Oersted (confirmed by Schulze's own observations), with ciliated gill-leaves; its two long frontal cirri are also ciliated, and so are the pair of longer appendages, which, seated on the second segment, project at right angles from the body, as noticed in a species found at Cuxhaven.

The claim of the TURBELLARIA to afford a refuge for these strangers, which, like homeless paupers passed from parish to parish, are found so difficult to settle, is next brought under review. All the Vortex-worms have a ciliated covering, spread entirely and uniformly over the body; their skin is soft and melting; their digestive canal is destitute of a firm envelope, and is separated from the soft parenchyme of the body only by its wall, formed of peculiar digestive cells, or hepatic cells. Muscle-threads, the central portion of a nervous system, and water-vessels, are recognized in all these worms.† In *Chæ-*

* *Archiv f. Anat. Physiol., etc*, 1853, p. 241, *et seq.*

† "In *Microstomum lineare*, in which neither Oskar Schmidt nor I could formerly discover any trace of a water-vascular system, I have lately recognized such, furnished with very small tremulous tags, and also distinct muscle-threads."—*Note by Dr. Schulze.*

tonotus and *Turbanella* the skin is not melting, but capable of resisting, to some extent, cold potass solution. It is ciliated only on the ventral surface, and, in the former genus, only on a portion even of this. The ring of cilia which surrounds the head of *Turbanella*, and the muscular coat of the alimentary canal of the Chætonotes generally, sharply defined against the parenchyme of the body, especially in the anterior third, are conditions unknown among the *Turbellaria;* while the motory muscles, nerve-threads, and water-vessels common to them, have not been recognized in those. Yet Dr. Schulze judges that a certain relationship between the *Chætonotidæ* and the TURBELLARIA is not to be mistaken: 1, because of their inarticulate body, in size and form resembling the little Vortex-worms; 2, because of the absence of any other locomotive organs than skin-cilia, by means of which, though covering only one half of the body, the animals yet proceed with a soft gliding motion, like that of the Vortex-worms; 3, because the absence of muscles, nerves, and vessels is approached by the obscure condition and receding development of these organs in many of the more minute *Rhabdocœla* and *Microstomata*. Thus there seems here a closer affinity than with the ANNELIDA.

Difficulties, however, beset the attempt to assign to the *Chætonotidæ* their natural place in the class TURBELLARIA. The *Dendrocœla* and the *Rhyncocœla* are at once excluded; the former consisting of animals of superior size, furnished with a ramified intestine without an anal orifice; the latter having, indeed, a straight intestine, provided with an anus, but invariably possessing a protrusile proboscis. There remain the *Rhabdocœla* and the *Arhynchia*.* Both these groups contain small forms, resembling those of the *Chætonotidæ;* but the former have an intestine without an anus, and a hermaphodite system of reproduction; the latter an anal orifice, but a diœcious reproduction. Thus the *Chætonotidæ*, hermaphrodite and furnished with an anus, cannot, without force, be referred to either.

In the TURBELLARIA, as in the VERMES generally, those characters which are drawn from the form of the alimentary canal have a higher systematic signification than such as depend on the condition of the reproductive system. If the *Chætonotidæ*, then, are to be placed among the TURBELLARIA, Dr. Schulze would associate them, not with the *Rhabdocœla*, but with the *Arhynchia;* which would include the *Microstomata* and *Dinophilus* as diœcious, the *Chætonotidæ* as monœcious forms.

Finally, this able zoologist, taking into consideration all the facts recorded, considers it premature to determine the actual

* Vide Schulze's *Beitr. z. Naturg. d. Turbellarien.*

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relation of the family in question. Assigning to them a provisional place among the TURBELLARIA, as just indicated, he admits that further investigations of the anatomy of this little examined group may bring to light relations hardly suspected; while many forms more or less closely allied may still lurk undiscovered, acquaintance with which may modify our already accepted conclusions. Dujardin's curious little *Echinodera*, and my own equally anomalous *Taphrocampa*, appear, for example, to widen the distance between the group and the TURBELLARIA; while, in their more strongly marked segmentation they show a decided approach to the Annelidous forms.

Having thus given to the reader an abstract of the views of one of the most learned of Continental zoologists on this obscure group, I proceed to describe all the species as yet recognized in it, premising that I have myself met with some, manifestly belonging to before-unknown genera, and other species which seem irreconcileable with published descriptions and figures of such as had been recognized. These I propose to include.

FAMILY CHÆTONOTIDÆ.

I think it desirable that the family should be named after the most characteristic and most populous genus, which is indubitably *Chætonotus*, and not *Ichthydium*. It consists of soft-bodied animals microscopically minute, of lengthened form, having a bilateral symmetry, with a more or less distinct separation of the head; the body more or less clothed with vibratory cilia, and for the most part with long hairs; the alimentary canal straight, and furnished with an orifice at each extremity. Inhabitants of fresh-water.

Genus I.—ICHTHYDIUM (*Ehrenberg*).

Posterior extremity forked; body unfurnished with hair.

Sp. 1. I. podura (*Müll.*) This form has been often seen by the early observers, if we can be quite sure that it has not been confounded with *Chæt. larus*. Ehrenberg first certainly defined it, having met with it in Nubia, among conferva from the Nile, and subsequently near Berlin. The body is linear-oblong, with the anterior extremity swollen; sometimes three-lobed; often slightly constricted; the hind fork short. The ventral surface is flat, the dorsal arched, and destitute of hair. The largest specimens have not the least vestige of hair on the back. The animal is colourless or whitish, but sometimes tinged with yellow, through the distension of the wide intestine. A longitudinal band of cilia was in one specimen clearly seen by Ehrenberg, along the belly, but in other individuals,

though of large size, he could not with the utmost care discern it directly, though he saw a distinct rotation at the mouth. It swims more rarely than it crawls. Our specimen showed, in the hinder part of the thick body, a large dark egg, well developed.

This species appears to be rare; I have not myself met with it, nor have I noticed any record of its occurrence since the publication of Ehrenberg's observations.

Genus II.—Chætonotus (*Ehr.*).

Posterior extremity forked; body clothed with hair.

Sp. 2. C. larus (*Müll.*) (Pl. i. Figs. 1—3.) This is the most commonly observed species of the whole family, being very frequently met with among duckweed, conferva, and other aquatic vegetation. It is of moderate dimensions, as compared with others, ranging from 1-400th to 1-200th of an inch in length. Its body is not quite four times as long as broad; the head is roundish or obscurely triangular, passing insensibly into the thick neck which separates it from the swelling abdomen. The posterior extremity is deeply forked, the two divergent toes tapering to points, which are sometimes obtuse. Ehrenberg distinguishes the species by its having the hairs on the hinder portion of the back longer than those on the fore part; and in this distinction I concur with him, the specimens that I have seen possessing the character strongly marked, sometimes excessively. These long hairs are few, and spring out of a dense coat of short hair, which clothes the whole body, but most thickly behind. Probably this is what M. Dujardin refers to when he remarks that "looking at it in profile we recognize that the back is covered with asperities from between which the long straight hairs spring." * No one that I am aware of has remarked a curious circumstance, that the sides of the head are furnished (Fig. 3) with some very long slender hairs, which stand out laterally, diverging, curving slightly forward, like the whiskers of a cat. I have observed the animal frequently bend and straighten them rapidly, near the tips, one independently of another, with a movement very different from an ordinary ciliary vibration. A strong ciliary current is produced on each side, by which floating atoms are drawn towards the head, and then rapidly hurled about halfway down the body. Vigorous ciliary currents are seen to pass along the inferior surface of the neck: I have not often been able to define these as forming two bands, though occasionally they are traceable, reaching nearly as far as the bottom of the posterior cleft, and then turning abruptly up and run-

* *Hist. d. Infusoires*, p. 570. See, however, *infra*, under *Das. antenniger*.

ning forward along the sides. The mouth appears to me oval, minute, slightly protrusile; Ehrenberg describes it as a tube furnished with eight teeth. It leads into a gullet with very thick transparent walls, and a very slender perforation, which, at about one-third the total length of the animal, enters a straight intestine, of equal diameter with the gullet-wall. This, as I have seen it, has been generally colourless, loosely filled with irregular clear masses, and apparently terminating at a curved transverse line, considerably above the fork. This line is doubtless the outline of the swollen arched back, and marks the position of the cloaca, which, as is frequently the case, is visible only at the instant of its function. Ehrenberg has induced the digestive organs to receive indigo. The same observer has frequently seen a large developed egg contained in the ovary, which occupies the arched cavity of the abdomen, situate over (that is, more towards the back) the intestine. The egg is about one-third as long as the whole animal. I have seen the reproductive system in an inactive condition, merely as clear, refracting viscera of large size, and irregular shape, lying in the abdominal cavity, occasionally extending forward to the neck. On one occasion I am pretty sure that *I saw, for a portion of its length, a tortuous water-vessel*, running down one side. (See Fig. 3.)

The movements of this little animal are smooth and graceful, a sort of gliding or creeping over the water-plants; rarely swimming. Once I saw a *Paramœcium* come blundering up against an unsuspecting *Chætonotus*, who instantly doubled his pace as if frightened, but soon recovered his equanimity. Mr. Slack says, that among threads of conferva or decayed vegetation, he has observed it grope about, and shake them like a dog. (See *Marvels of Pond Life*, p. 84; where are two excellent figures of the species, and some interesting notes of its manners.)

Sp. 3. C. maximus (*Ehr.*) (Pl. i. Figs. 4 and 5). This is about twice the size of the preceding, measuring from 1-120th to 1-200th of an inch. The body is lengthened, slightly constricted, with the head turgid and obtusely triangular; the hairs on the upper surface short and equal. Such is Ehrenberg's definition of the species, who adds that the mouth is furnished with about eight feeble teeth (possibly papillæ). The distribution of the bristles in one he observed in distinct longitudinal rows; in another the arrangement appeared irregularly diagonal. A single egg is developed at once, greatly dilating the dorsal region of the abdomen, which Ehrenberg saw discharged by the cloaca above the foot-fork; he saw the germ-vesicle distinctly.

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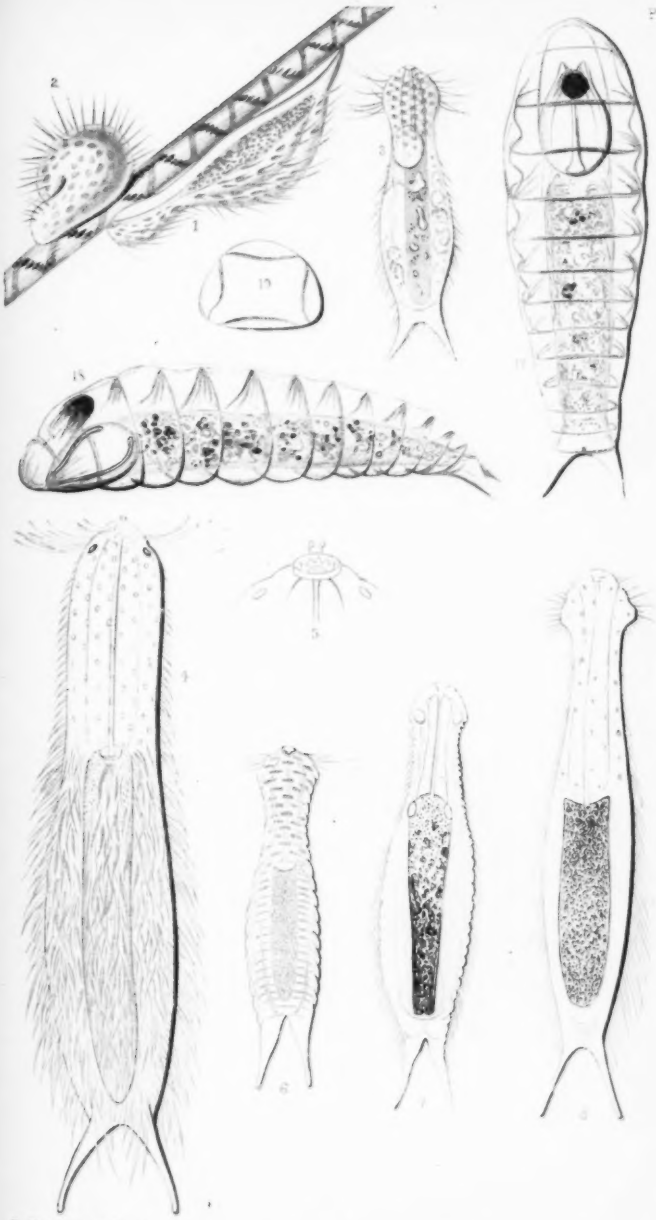

P. H. Gosse, ad v.v.

HAIRY-BACKED ANIMALCULES.
Chætonotidæ.

1, Chætonotus larus, crawling on a thread of Conferva; 2, in the act of turning; 3, viewed from above. 4, C. maximus; 5, the mouth and oculiform specks, more highly magnified. 6, C. squammatus. 7, C. Slackiæ. 8, C. gracilis. 17, Taphrocampa annulosa, viewed from above; 18, viewed from the left side; 19, ideal transverse section.

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C. larus may be identical; but surely without good reason. He has added a good deal to our knowledge of its minuter anatomy; in particular he does not find the bristles of equal length, but longest on the back and hind end; and states that each is a pointed spine *furnished with two minute subordinate spines, one springing on each side of its base.* These spines are processes of the skin, not hairs inserted into it; but they are dissolved by potass more readily than the skin itself. The belly surface is quite destitute of spines, but it is uniformly clothed on the anterior half with short cilia, which on the posterior half are ranged in two bands along the edge, uniting above the fork. The median line of the belly is clothed with a row of short stiff down lying backwards.

The mouth, surrounded by eight or ten long, soft, and immoveable slender hairs, is formed by a circular membrane, either finely plaited, or beset with minute prominences ("teeth" Ehr.), protrusile, in the form of a short tube. Schulze recognizes the great egg with its germ-vesicle, and adds that it is covered with a shell, which potass does not dissolve. He also finds in front of the ovary a cellular spermatic gland, and two groups of spermatozoa; but fails to detect any trace of nerves, muscles, water-vessels, or tremulous tags.

In August, 1851, I found in a dyke near Stratford a very large *Chætonotus*, which I am disposed to refer to this species. Its length was 1-70th of an inch, its greatest width 1-400th (but including the bristles 1-300th); length of the toes 1-580th. The dimensions, equal to those of a full-grown *Notommata aurita*, rendered it distinctly visible to the naked eye, and marked it from all others known to me. It was equally marked by its dense coat of rigid, spinous bristles, set all over the body on the upper surface and sides, and which are longer towards the hinder parts. The toes are small, slender, slightly knobbed and incurved; they can be made to approach, and even to cross each other. On the anterior half of the body the bases of the bristles are evidently set in quincunx in about eight rows visible; the spots are very distinct and strong. On the posterior half, the increased length and decumbency of the bristles cause a brown opacity and roughness; through which, however, the cylindrical intestine can be seen by focussing. The head is but slightly lobed, and the neck scarcely at all constricted. The mouth consists of a short tube, evidently protrusile, with a dark oval speck at the bottom in the centre, where a straight slender tube originates, and passes through a wide cylindrical œsophagus to the intestine, the head of the latter embracing its fundus. On the front and at each side of the head are very delicate curved hairs like vibrissæ. Just below the lower edge of the mouth are placed two minute hooked organs, the

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end of which seem thickened and are bent downwards. Oval clear specks, one on each side of the face, may be eyes. (See Fig. 5.)

The manners were much like those of the rest of the genus. It was restless, crawling impatiently among the little masses of sediment, frequently turning itself double, and sometimes coiling almost into a circle; perpetually shortening and lengthening the head, protruding the mouth, and searching with the fore part, like a caterpillar. It sometimes swam briskly.

A much smaller individual, from the same dyke, had the bristles much fewer; they were, however, very coarse, and rigid and curved. A row of fine close-set vibrating cilia run along the side besides the bristles. I think it was a young one of the same species.

In a specimen recently dead, and lying on its side, I saw the lateral form of the mouth, and the traces of tooth-like striæ that surround it. I saw no bristles along the belly line, but they covered the whole sides. Certain irregular lines may possibly have been folds of the skin. The intestine was decurved, and terminated considerably short of the fork; it appeared to have a distinct portion at its anterior end, separated by a diaphragm. The toes were decurved. *I did not notice* the peculiar structure of the bristles observed by Schulze, but cannot affirm that it was not present.

Sp. 4. C. brevis (*Ehr.*). This is characterized by its minute dimensions, being only 1-430th of an inch in length, and by its having several eggs developed simultaneously, which are proportionally smaller. A doubtful species, and one which has not, I believe, been recognized by any other observer.

Sp. 5. C. squammatus (*Duj.*) (Pl. i. Fig. 6.) The hairs enlarged in the manner of scales, regularly imbricated, distinguish this species. M. Dujardin found it in January 1840, in a bottle of fresh water which he had kept for more than a year, having brought it originally from Paris to Toulouse.* On the upper surface it appears clothed with scales ranged in seven longitudinal rows, but on a side view these are seen to be the bases of short hairs which cover all the back, and even the forked foot. The mouth appeared surrounded by four or five papillæ, only occasionally visible. The vibratory cilia of the ventral surface are very long, especially on the anterior portion.

In 1850 I found what I presume to be this species, in a tub of water exposed in my garden for the propagation of Rotifera. A description, made at the time, without any knowledge of Dujardin's observations, I subjoin. Length 1-170th of an

* Pritchard (*Infus.* 4th Ed. p. 662) by mistake says "*sea* water *from* Toulouse."

inch. In form this resembles *C. larus*, being rather broad in proportion to the length. At first sight the body seems quite smooth, but on bending strongly to either side, it is seen to be clothed with hair, as it were agglutinated in locks, like human hair wetted; for these locks then separate. The outline of the head is slightly five-lobed, and on each side of the face there are several long slender bristles diverging laterally, like the whiskers of a cat. Along the ventral surface run two rows of vibratile cilia, extending the whole length; they appear to be longest near the front. I distinctly saw them in vibration throughout, and the motion communicated by them to the floating atoms was strong and conspicuous; these, however, were hurled backwards longitudinally only, with no trace of vortices.

The mouth, œsophagus, and alimentary canal do not differ from those of the next species; but the surface of the body presents something peculiar; it appears to be thrown into a number of transverse or annular wrinkles, possibly produced by the arrangement of the hair in locks. On the front third a number of transversely oblong dark spots are seen, arranged quincuncially with much regularity; their nature I could not determine, unless they also be divisions of the matted masses of hair; they are certainly not spots of positive colour. The whole animal is colourless; the intestine was granular, but appeared empty; it would not imbibe carmine. No reproductive organs were discernible. The forked toes are blunt at the tips; they are sometimes widely separated; that they are soft was manifest when one was bent by pressure against the glass, as the animal turned. It possesses the power of contraction and elongation to a slight extent; in the former the transverse wrinkles become more distinct, and the animal becomes shorter and broader. My specimen was very active, crawling nimbly, and swimming with much swiftness, but in an unsettled wandering manner. The body is very flexible, frequently turning so short as to be bent double.

Sp. 6. C. Slackiæ (*Gosse*). (Plate i. Fig. 7.) This undescribed species I venture to dedicate to a lady, to whose facile and elegant pencil microscopists are so much indebted for the beautiful and truthful delineations of *The Marvels of Pond Life*. I obtained it in January, 1851, from the sediment of the garden-tub already alluded to. Its length was 1-135th of an inch; its greatest breadth 1-600th. The proportions are nearly those of *C. larus*, but the outline of the head is the half of a short ellipse, without lobes, and it passes, with an abrupt angle, into the neck, which is somewhat more slender in proportion to the body than in the species just named. This form of the head gives a peculiar aspect to the physiognomy, and is the first appearance of a

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character which is more marked in the following species, and more strongly still in the genus *Dasydytes*. The upper surface of the body is conspicuously studded with quincuncial dots, the optical effect of what I judge to be tubercles or warts so arranged, from which, perhaps, the hairs spring. (In the engraving I have not indicated this reticulation, that I might display more clearly some important particulars of the internal anatomy.) The back and sides are clothed with very fine hair of only moderate length, which is directed backwards. I did not detect any trace of facial vibrissæ.

The mouth is rather larger than usual, abruptly narrowed behind. The œsophagus is of the normal form, a cylinder with very thick transparent walls, centrally pierced by a slender tube. I was surprised to observe that the œsophagus did not embrace the mouth, but appeared to commence just behind it, by a peculiarity of structure not easy to explain (perhaps a sudden dip or angle carrying it out of focus, though in incessant manipulation, such a circumstance could scarcely have been undetected), apparently with a depressed centre, where the medial perforation began. (See Fig. 7.) Imbedded in the exterior wall of this viscus, on each side of its summit, was a minute oval dot, well defined, which at times appeared to have positive colour, and which reminded me of the eye-specks of Rotifera. At the posterior extremity of this perforated viscus (which in ignorance we call the *œsophagus*), about one-fourth of its length, having a vaulted figure, seemed separated by a delicate bounding line from the rest. The posterior extremity was slightly excavated, and seated upon the correspondingly convex summit of the intestine,—another deviation from the normal condition, in which the intestine embraces the œsophagus in a hollow. On each side of the summit of the intestine an oval clear vesicle was seated, having the appearance, situation, and doubtless function, of those glands which, in almost all Rotifera, we assume to be pancreatic.

But the most interesting result of examination was the indubitable discovery of a water-system on the plan of that of the Rotifera. Serpentine vessels ran along each side of the body-cavity (two visible on one side, one only on the other), which could be traced very distinctly (especially when the animal bent itself laterally) nearly to the fork, and in front to the occiput, where each ended in a clavate bulb. Immediately in front of this pair of bulbs, but not having any visible connection with them, were two globular vesicles, which refracted the light strongly, and were probably filled with some fluid. These were not distinct in the same focus that defined the minute eye-like specks, and hence must have been in the opposite (ventral) region of the head-cavity. After a while, one only of

these could be found, the other having vanished. Are they, then, contractile vesicles? The other viscera presented nothing remarkable.

Sp. 7. C. gracilis (*Gosse*). (Pl. i. Fig. 8.) This elegant species, which I obtained from a pond near Leamington, in July, 1850, is remarkable for the slenderness of its form, which is not broader than that of *C. larus*, while it is about twice its length. The head is dilated at the occiput, where it is abruptly joined to the narrow neck, somewhat triangular, divided into five well-marked rounded lobes, and fringed on each side with laterally-diverging straight hairs. In the middle of the frontal lobe is pierced the mouth, which is of the same form as in *C. Slackiæ*, with slightly protrusile lips. The œsophagus is of the ordinary form, but its anterior extremity is conterminous with the front of the head, with no such structure, and no such accessories as are seen in the species just named. Its length is unusual, for it extends nearly to the middle of the body, where, just before it enters the intestine, the thick muscular wall suddenly narrows, till it seems commensurate with the tube itself. The intestine is concave at its commencement, or rather, perhaps, it is furnished with a pancreatic gland on each side, which, as is frequently the case in the Rotifera, is pointed and ear-like. This suggestion, however, rests merely on the form; for I have not detected any bounding line between the points and the intestine, nor was their substance clear, but densely filled, as was that viscus, with finely granular matter. The rounded termination, marking doubtless the position of the cloaca, is on the descent of the back, some distance in front of the foot-fork.

I was not able to discern any internal organs besides the alimentary canal, though the opacity caused by the hairs was much less than usual. The anterior half of the body shows the bases of the hairs, like very delicate dots set in quincunx. The sides and back are armed with fine bristles curving backwards. The points of the foot-fork are slender, sub-cylindrical, and slightly dilated at the lips, which are decurved.

The animal crawls impatiently about, apparently seeking for food; for I several times saw it eagerly snap at a Monad, that roamed near, opening the mouth at the same moment. Once *I believe* I saw it seize and swallow the prey, though as it was the work of an instant, I could not be quite certain. I have obtained but one specimen of this species.

Genus III.—Dasydytes (*Gosse*).

Head distinct: posterior extremely simple, truncate; body furnished with hair.

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Sp. 8. D. goniathrix (*Gosse*). (Pl. ii. Figs. 9—12.) Hairs long, each hair bent with an abrupt angle; neck much constricted.

This and the following species I briefly defined, and formed of them the genus *Dasydytes*, in the *Annals of Natural History*, for Sept. 1851. The present very remarkable form was obtained from a pool at Leamington, in July of the preceding year. The length of the body is 1-150th of an inch; measured to the tips of the bristles, 1-110th. The head is nearly circular, as wide as the body, without lobes, but abruptly separated from a slender neck. The mouth takes the form of a *permanently* projecting truncate lip, or short tube. The body is rather slender, swelling toward the hinder part, and tapering to a rounded or truncate point, without any trace of the ordinary forked foot. A most peculiar and bizarre character is imparted to the creature by its clothing of very long bristles, set along each side of the back, pointing obliquely backward, but apparently wanting along the mesial line, which rises into a ridge. Each bristle is bent near its tip at an abrupt angle (see Fig. 12), so that it looks as if it had been broken and mended. The front of the head is furnished with long delicate hairs, not geniculate, which form two pencils directed backward, one falling on each side. Strong and conspicuous vortical currents were produced on each side of the head, like those of the true Rotifera (Fig. 9), and in one specimen I distinctly saw that they were caused by these frontal pencils of hairs, and that these were very long vibratory cilia. The ventral surface is set with short fine hair, which becomes longer behind (Fig. 10); doubtless cilia of unusual development, for they produced strong longitudinal backward currents, continued from the frontal vortices.

The tube of the œsophagus is always distinct, but the walls are to be discerned only when the animal is flattened by the compressorium. Then it is seen to be fusiform, instead of cylindrical, extending through one-third of the body, where its tube enters a wide cylindrical intestine, with a broad abruptly truncate anterior extremity; of this a short portion is clear, when the remainder is occupied with opaque granular food, and possibly may represent a pancreatic gland of abnormal form, as it embraces the hinder part of the gullet tube, or else is perforate with a similar tube (see Fig. 9). But in one specimen this very portion was intensely opaque, while the intestine was granular. The cloacal orifice seems to be at the very extremity of the body, as no termination of the intestine, nor even any diminution of its diameter, can be discerned short of that point. On repeated occasions I have seen the act of defecation, in one of which an oval clear corpuscle was dis-

charged, which, before, as it lay near the extremity of the body, had much puzzled me: it was probably the undissolved envelope of a minute animalcule, which had been devoured.

In one specimen, a large very clear viscus of irregular form occupied the widest part of the body, above the intestine, elevating the back into a hump. After some hours this viscus, which at first appeared structureless, developed an egg-cell with its nucleus, thus proving to be the ovary. The entire animal is of a pale smoky colour. It does not crawl like the Chætonotes, but habitually swims swiftly about, keeping, however, near the bottom of the water.

Fig. 11 represents an individual as it appeared after it had become sluggish, and apparently dying; it is evidently a view lengthwise along the back, the lower part, or that next the observer, being, I believe, the head. It is valuable as showing the arrangement of the angled hairs.

Sp. 9. D. antenniger (*Gosse*). (Pl. ii. Figs. 13, 14.) Hairs short, downy; a pencil of long hairs at each angle of the posterior extremity; head furnished with two club-shaped organs resembling antennæ. The horse-pond on Hampstead Heath yielded me this species, in August, 1850. It is a little smaller than the preceding, the length being only 1-170th of an inch; but measured to the tips of the hairs, 1-140th. In general figure, and in some particulars of its organization, it appears to diverge less from *Chætonotus*, than the preceding species does. The head is round, as wide as the body; and there is but little constriction at the neck. The upper surface is covered with short but dense hair pointing backwards, and apparently set in quincunx; the posterior extremity is somewhat three-lobed, the middle lobe furnished with a terminal brush of diverging hairs, the outer lobes each bearing a pencil of much longer hairs proceeding from its exterior side, and approaching or crossing the opposite pencil at the tips (Fig. 14). From the front of the head projects the prominent tubular mouth; on each side of which long hairs fall backward as in *D. goniathrix*, and these, by their vibration, cause a perfect vortex on each side (see Fig. 13), while there is an accessory current also down along the side, and probably all along the belly. But the most remarkable feature in this species is the presence of a pair of antennæ or tentacles; these are nearly as long as the width of the body, are slightly clubbed, and are placed one on each side of the tubular mouth, whence they spring in a curve forwards and outwards. Near the middle of the head is a little rounded mass, somewhat curdled in appearance, which I take to be a cerebral ganglion. An unusually wide and long œsophagus, ventricose behind and permeated by a tube through its centre, leads from the mouth

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to a nearly cylindrical intestine. This widens a little in front to embrace the bulbous end of the œsophagus, and extends nearly to the posterior extremity. It was filled with food of a rich uniform green hue, and contained many air-bubbles, especially towards its fore part. On each side of the fore part of this viscus, I could indistinctly trace a lengthened slender body, apparently a tortuous vessel, which on one side seemed to be connected with a small oval clear organ. From the fact that sometimes it was quite plain, while at others I could not discern any trace of it, it may probably have been a contractile vesicle. The whole outline of the animal appeared to have a wavy or notched character, indicating a tuberculous surface, as in *C. Slackiæ*, if it was not an optical illusion, and caused by the hairs.

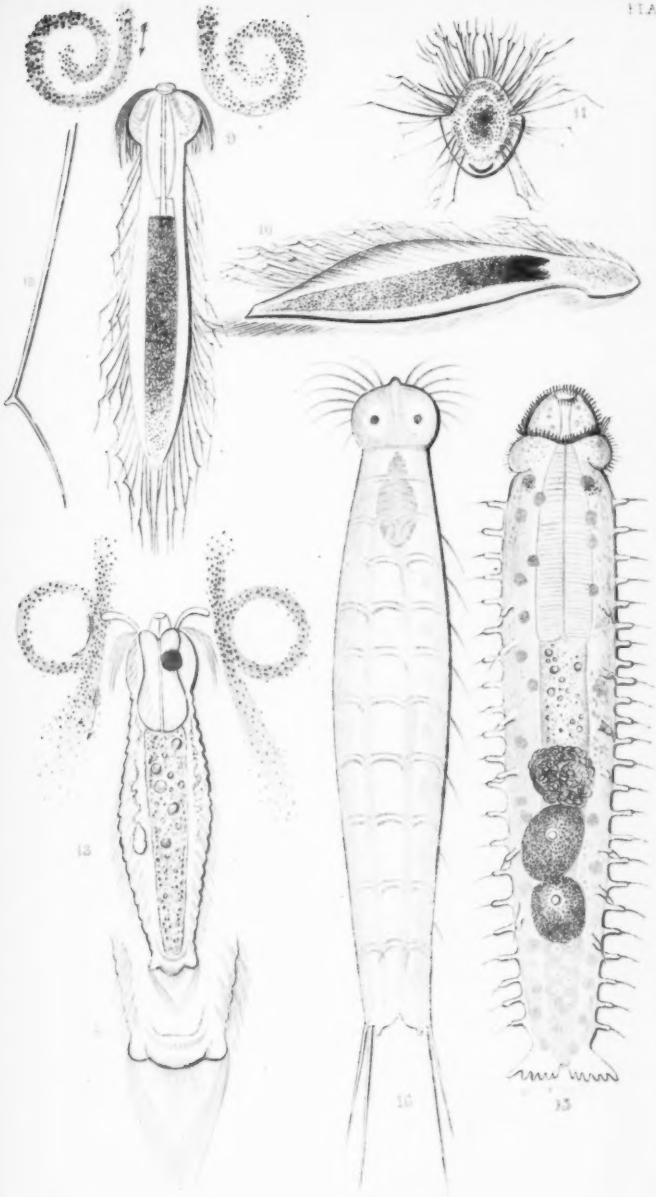
This little animal was very active, swimming with much rapidity, and rarely becoming still; when confined in cells formed by wool-fibres it was most persevering and often successful in forcing the barriers, by getting its thin flat head under a fibre, and pushing until it forced its body through also.

Genus IV.—Turbanella (*Schulze*).

Head distinct, surrounded by a ring of cilia; body naked above, clothed with cilia beneath; two rows of bristled processes along each side; posterior extremity a broad flat plate with a central division.

Sp. 10. T. hyalina (*Schulze*). (Pl. ii. Fig. 15.) Length 1-60th to 1-48th of an inch; width 1-480th to 1-360th. The body is lengthened, somewhat flat, transparent, colourless; separated by a strangulation from a rondo-triangular head, which is wholly covered with fine cilia, and bears besides a wreath of strong cilia around its centre. The hinder extremity expands into two hard flat plates, which are indented comb-like on their edge, and are divided in the middle by a sinus, into which opens the cloaca. At nearly regular distances, all along each side of the body, are placed stiff processes of the skin, to the number of twenty to twenty-five, projecting at right angles horizontally; and above these another row, consisting of six or eight similar processes, inclined backward, making from fifty to seventy in the four rows. Each process bears at its tip an excessively fine immoveable seta of about its own length. These processes as well as the skin itself were found to be quite soluble in potass, and therefore are not composed of *chitine*.

The alimentary canal runs in a straight line through the whole length. The mouth, opening on the rounded front of the head, and surrounded by a finely-plaited and indented edge, leads into the usual œsophagus with very thick transparent



P. H. Gosse, ad vivum.

HAIRY-BACKED ANIMALCULES
Chætonotidæ.

9. Dasydytes gonathrix, viewed from above; 10, viewed from the right side; 11, viewed from the front; 12, one of the bristles greatly magnified.
13. D. antenniger; 14, the caudal pencils more highly magnified. 15. Turbanella hyalina, after Schmise. 16. Echinodera Dujardinii, after Dujardin.
N.B.—All the figs., except 8, 14, and 15, are magnified 300 diam., and all, except 15 and 16, are from the life.

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muscular walls, which terminates at about one-fourth of the body-length. The perforation is so slender as to be detected only while a morsel is in the act of being swallowed. The intestine presents nothing remarkable, except that in its yellowish granular wall containing fat-cells, Dr. Schulze thinks he finds a hepatic function. The body-cavity is occupied by a finely-granular, soft parenchyma, the corpuscles scattered in which are not driven to and fro by the movement of the body, in which therefore a somewhat firm consistence is inferred. No trace of a muscular, nervous, or vascular system was discovered, though many individuals were carefully examined.

The animal is hermaphrodite. A great ovary lies in the posterior half of the body, over the intestine, in the hinder portion of which are contained the incipient egg-germs, consisting of vesicle and speck, which are developed in the anterior portion, becoming surrounded with a granular yelk. Generally one or two eggs are found freed from the ovary, enclosed in a special soft colourless envelope. In front of these mature ova lies the spermatic gland, a mulberry-like mass of cells, and close to it two groups of spermatozoid germ-cells, apparently unenclosed, lying free in the parenchyma. In some examples the spermatozoids were developed, but showed no spontaneous motion.

The specimens described occurred to Dr. Max Schulze in sea-sand from Cuxhaven, with *Desmideæ* and *Diatomaceæ*. They swam with a gentle gliding movement, like the *Turbellaria*.

Genus V.—Echinodera (*Dujardin*).

Body articulated; set with few bristles; head distinct; posterior extremity truncate, with two short processes, and spines.

Sp. 11. E. Dujardini (*Gosse*). (Pl. ii. Fig. 16.) As the discoverer and describer has not assigned any specific name to his animal, I take the liberty of honouring it with his own. M. Dujardin obtained the form in July, 1841, in sea-water from St. Malo, which had been kept for six months. The generic name, signifying "spinous neck," he selected to show its relations with *Echinorhynchus*. The body, 0·30 mm. to 0·55 mm. (about 1-75th to 1-50th of an inch) long, is oblong, almost cylindrical in front, a little flattened behind, where it terminates by two great bristles, accompanied by two other bristles of smaller size, like those we see at the extremity of the *Cyclopidæ*. The body is composed of ten segments, without counting the head, which is retractile, bristled with long and flexible spines, and without counting the caudal laminæ (*lames*) which accompany the terminal setæ, making the total number of seg-

ments twelve. The first segment of the body is united to the second by a simple intersection; all the rest are separated by a horny arch very distinct, presenting three articulations on the plane or ventral face, viz., one answering to the axis, and two lateral, between the edge and the middle. Each segment encloses the next, and appears laterally armed with two points or spines imbedded in the rear. It is covered, or simply bordered with cilia, extremely fine, not vibratile, and very difficult to perceive.

Under the first or the second segment, according to the state of retraction of the trunk, we perceive in the interior two red oculiform specks, which pertain to the retractile and protractile portion of the digestive apparatus. To the extremity of this retractile portion extends the œsophagus, longitudinally plaited in the interior, and furnished in front with a coronet of lobes, or teeth, which represent the mouth. The membranous and plaited tube of the œsophagus is covered by a thick muscular layer (*couche*), forming a cylinder 0·035 mm. wide, and 0·092 mm. long, which occupies the 3rd, 4th, and 5th segments of the body, and which, swollen in the middle, takes the form of the pharyngeal bulb of some worms. The stomach, which succeeds, is cylindrical, 0·040 mm. wide, 0·17 mm. long, and contracts itself from the front backward by successive waves: it is invested with a brownish floccose layer, which appears to represent a liver. Finally, a slenderer portion of the intestine occupies the tenth segment, and terminates between the two caudal plates.

M. Dujardin has since found it, on repeated occasions, in sea-water, on oyster shells, etc., always with the same form and characters, without ova or genital organs. "If I had not seen it," he remarks, "always alike in vessels preserved more than a year, I might have supposed it the larva of some animal that had escaped my researches. Incomplete, however, as are my observations, after having vainly sought to add to them through ten years, I believe that they suffice to show a type differing from those of the Helminthes acanthocéphales, the Systolides or Rotifera, the Entomostraca Copepoda, and the Sipuncles, and at the same time offering points of resemblance to each of these. It is a sort of *Copepode*, without feet, with the mouth of a *Sipunculus*, and the neck of a *Echinorhynchus*, and a muscular œsophagus like those of the Systolides (Rotifera), the Tardigrades, and the Nematoid Helminthes."

Genus VI.—Taphrocampa (*Gosse*).

Body articulate, destitute of hair; posterior extremity forked; mouth a mastax, with mallei and incus, which are incurved.

Sp. 12. T. annulosa (*Gosse*). (Pl. i. Figs. 17—19.) This species and genus I defined in the *Annals of Nat. Hist.* for Sept. 1851, collocating it with the *Notommatæ* and *Furculariæ*, but indicating its relations with *Chætonotus*. It occurred to my researches in a pool near Leamington, in July, 1850. Its length is about 1-110th of an inch. The form is very larva-like; the body is sub-cylindrical or fusiform, terminating in a bifid foot; it consists of many rings or segments, which are set within the clear cylindrical integument, and are themselves of a sub-square form, with projecting angles. Thus a transverse segment would present the appearance of Fig. 19;—a structure not easily explained. I could see no appearance of vortices, nor even the vibration of cilia; yet the form of the mastax is Rotiferous, and appears closely to resemble that of *Furcularia gracilis* and of the *Monocercæ*, consisting of an incus, with a long fulcrum and a pair of long incurved mallei. The animal can bring the tips of the jaws to the front, and nibbles extraneous matters with them like the *Notommatæ*, etc. A long, wide, straight, cylindrical alimentary canal, without any accessary glands or constriction, leads from the mastax to the cloaca just above the forked foot. It was in this specimen nearly empty, slightly tinged with yellow. All the rest of the animal was colourless. No eggs or ovary were visible. At the occiput, behind the mastax, was an opake mass, which was white by reflected light, but showed no redness or appearance of eye, by either reflected or transmitted light. Like the cerebral ganglion in many *Notommatæ*, it lay at the bottom of a wide deep sac (Fig. 18). The animal contracts strongly and continually like *Notommata;* but the sphere of the contraction is the space occupied by the alimentary canal, the parts outside the boundary lines of this remaining still, while the parts within retract forcibly, and both ways, but chiefly from behind forwards. In its movements it resembles *Chætonotus*, crawling sluggishly about the glass and the particles of sediment. I never saw it attempt to swim.

The number of genera has thus been increased, since Dr. Schulze wrote his summary of the family, from four to six, and of species from seven to twelve. With these augmented materials it seems to me that the judgment expressed by him as to their affinities must be somewhat modified, and I have no hesitation in recurring to the original decision of Ehrenberg, and in placing the *Chætonotidæ* among the Rotifera. Tortuous canals and a contractile vesicle I have seen in *C. larus*, *C. Slackiæ*, and *Das. antenniger:* pancreatic (?) glands in *C. Slackiæ;* ciliary vortices are made by *D. goniathrix* and *D. antenniger*, not to be distinguished from those made by many Rotifera, as *Furcularia*, *Notommata*, etc. The egg-develop-

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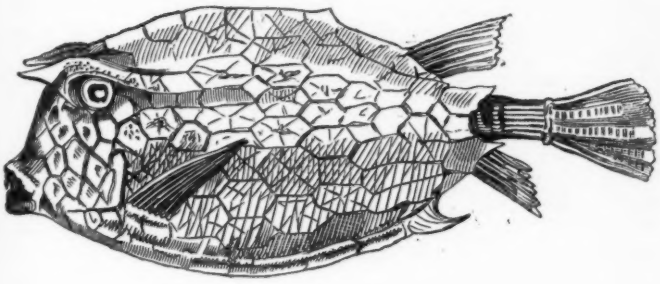
ment, the great size of the egg, and its chitinous shell, are decidedly Rotiferous.* A great cerebral ganglion, exactly corresponding to that of *Notommata aurita*, *N. tripus*, and others, is found in *Taphrocampa*, and indistinctly in *D. antenniger*. The mastax, so eminently characteristic of ROTIFERA, is fully developed in *Taphrocampa*, where, however, the form and extent of the alimentary canal are as in *Chætonotus*. The furcate posterior extremity is not a tail but a foot, as in ROTIFERA, the cloaca opening on its dorsal side; it is not indeed separately moveable even in *Taphrocampa*, yet its homology with the foot of *Notommata* cannot be overlooked; it is wanting in *Turbanella*, *Echinodera*, and *Dasydytes;* so it is in those true ROTIFERA, *Asplanchna* and *Anurœa*. The very long attenuate hairs that radiate from the face in several (perhaps in all) of the *Chætonoti*, which have a singular power of independent vibration, recal the very similar vibratile setæ of *Floscularia* and *Stephanoceros;* and possibly the little hooked organs which I find on the front of *C. maximus*, and the club-shaped horns of *D. antenniger*, may have a parallel in the frontal hooks of *Melicerta*.

In short, if *Taphrocampa* has a true affinity with *Chætonotus*, there can be no question that the family belongs to the ROTIFERA. It is true there are important diversities between these genera, but there are forms which bridge the hiatus. *Echinodera* seems to approach closely to *Taphrocampa*, but *Echinodera* has much in common with *Dasydytes*. *Turbanella* is very peculiar, yet I doubt not Schulze is right in allying it with *Chætonotus*. It is, doubtless, a group whose members manifest great diversity; but probably there remain many forms to be discovered which will further facilitate transition from one to another, and illustrate its exterior relations.

In the cilia-ring on the head of *Turbanella* in its curious setiferous lateral processes, in the form of its head, in the annulation of *Echinodera* and *Taphrocampa*, and in the long hairs of *Dasydytes*, especially the terminal tufts of *D. antenniger*,† there seem to be some strong points of alliance with ANNELIDA, and I am inclined to place the family on the border-ground between these two great classes, the ROTIFERA and the ANNELIDA, with a preponderance of characters belonging to the former.

* The relative position of the reproductive and the digestive organs is, however, contrary to that which obtains in the ROTIFERA; in which the latter are dorsal the former ventral.

† I beg to refer, for descriptions and figures of the young forms of some marine Annelida, to my *Tenby*, p. 279, and Pl. xv.



THE FOUR-HORNED TRUNK FISH: A NATIVE OF ENGLAND.

BY JONATHAN COUCH, F.L.S., ETC.

It was formerly believed that the fishes of this remarkable genus were to be met with only in the far East, or, at least, nowhere except in very warm climates; and although when voyages had become frequent along the coasts of Africa and India several species became known to the observers of Nature, they were for a long time regarded only as strange freaks of Nature, which might add a new interest to the cabinets of the curious, but of which the habits and distribution over the globe could be only a little studied. There were indeed a few particulars about them in which naturalists who were not travellers were fortunate; for with only a little care they might be conveyed home without distortion of shape; which was far from being the case generally with numerous fishes of other classes that were imported into England from the same regions—illustrations of which may be seen in the representations of the fishes of Amboina in the work of Ruysch, entitled *Theatrum omnium Animalium;* and there is even reason to believe that the distortions inflicted on some were made designedly, for the purpose of rendering what was strange and remarkable, still more hideous or curious.

Jonston published his *Natural History of Fishes and Whales* in the year 1649, and in it, under the name of *Piscis triangularis*, he has given a figure of two species (Plate 45); but there is no reference to either of them in his text. It is one of these, however, to which I would call the attention of British naturalists, as laying claim to be regarded as a lately-discovered, and, of course, rare visitor to our own shores—the evidence of which will be presently adduced, but concerning

which Willoughby appears to be as much at a loss as Jonston; for although he gives a good figure of it in his Plate I. 14, under the name of *Piscis triangularis cornutus Elusii*, he sums up all he knows of its history in saying, that there was an example in the Museum of the Royal Society. Linnæus appears to notice the same fish under the name of *Ostracion quadricornis;* but even in his day he supposes the whole genus to be confined to the seas of India. And that any of them should be found in Europe was not expected, until the researches of Risso led naturalists to understand that a few examples which belonged to two species had come within his notice in the neighbourhood of Nice. These are, *Ostracion cubicus*, Lin., and *O. trigonus*, Lin.; and this writer assures us of the certainty of what he relates concerning them, although he appears to have been prepared for the incredulity with which his statement would be received by many naturalists. A third species seems to be hinted at by Dr. Gulia in his *Tentamen Ichthyologiæ Melitensis* (p. 40 of the *Discorso sulla Ittiologia*); but as no description is given, and it had not come under his own inspection, we are not at liberty to refer it to the species presently to be described. But the question is of no small interest concerning the authority on which we claim for our own the example, of which we give a figure taken from the specimen; and to this the reply is short and precise. The first intimation of the alleged fact of the capture on our coast of an example of the four-horned trunk fish, was received from Robert Lakes, Esq., of St. Austle—himself a well-known naturalist, although chiefly in the department of ornithology—and as regards veracity he is beyond a doubt. So curious a fact as the taking this fish on the coast of Cornwall, could not fail to lead to further inquiry; in reply to which, the fish itself was sent, with the information that it had been obtained from a fisherman of Mevagissey, on the south coast of Cornwall, and that this man affirmed he had taken it in a net at some rather considerable distance from land; and, it was added, that this fisherman was considered to be of sufficient credit to warrant the belief that the information he gave might be relied on. It appears certain that this individual could not have been influenced by any motives of gain in the information he gave about this fish, for the remuneration given him was slight, if, indeed, he received any reward whatever. It was elicited also, on further inquiry, that a fish exactly similar had been taken about two years before this by a man of the same place.

The character of this genus of fishes is, that the head and body are covered with regularly-formed bony plates, which are united together in such a manner as to form a crust or unbending shell like a coat of armour, from which structure they

derive their name; and the only moveable parts are the mouth and lips, a slight border to the slit which constitutes the opening of the gills, the fins, and tail with its base or joint. There are real teeth in the jaws; dorsal and anal fins single and far behind, but no ventrals. As the firmness of the crust does not allow of motion in the body, the flexibility of the joints of the back-bone is unnecessary, and therefore they are united into one.

The length of the specimen is ten inches, of which the crust measures seven inches and seven-eighths; the height three inches and three-eights where deepest. The head slopes suddenly from the eyes. The general form compressed, sharp along the back, flat and wide on the belly; the section of the shape, therefore, triangular. Eyes, in front, elevated; and above each a prominent ridge, from which projects forward in a slight curve a stout spine—the pair resembling horns. The snout projects a little, mouth small, lips covering a row of conical teeth—the upper row eight, below six, as far as they can be counted. Gill openings, a perpendicular slit. The back rises in a ridge from between the eyes, and slopes down again toward the dorsal fin; and about an inch and a half before this fin is a small elevation—the fin itself narrow at the root, but extended. Anal fin further back, nearer the tail than the dorsal. A prominent spine posteriorly on each margin of the flattened under-surface, from which the thin border rises to the place where the moveable caudal portion protrudes from the case in a straight rudder, ending in a caudal fin—the ends of which in this example are injured. The head and body are covered with hexagonal plates, marked in lines round a raised centre. The pectoral fin narrow. Colour, yellowish-brown, but obviously faded.

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1. Fontinalis antipyretica (nat. size).—2. Stem-leaf.—3. Fruit.—4. Perichætial Leaf (mag.)

THE SIDE-FRUITING MOSSES.

BY M. G. CAMPBELL.

(*With an Illustration.*)

HITHERTO we have treated only of the Acrocarpous, or terminal-fruiting mosses, and though we have, from want of space, left unnoticed many of the most beautiful of that section, as the *Bryums*, *Muiums*, *Sphagnums*, etc., some of which we may describe hereafter, we purpose to devote this paper to the *Pleurocarpi*, or side-fruiters, and of these, the three Fontinaleæ, or water-mosses, fruiting in June and July, have a fructification eminently microscopic: indeed, so buried is the fruit within the leaves of the perichætium, which, like a large imbricated, persistent calyx, conceals, and appears almost to smother, the little seed-bearing urn which nestles within it, that any one unfurnished with a tolerable lens might well be excused for pronouncing them barren, even when rich, as they frequently are, at the lower part of the elder stems, with little branchlets bearing numerous immersed capsules.

The Fontinaleæ are pleurocarpous perennial mosses, growing

in water, chiefly in rivulets, where their rooting base attaches itself to stones or stumps of trees, and the rest, *i. e.*, the stem and branches, float hither and thither with the stream, like so much vegetating hair; being weak, flexible, and somewhat fragile, and the lower part of the stem being nude, or almost nude of leaves; the cellular tissue apparently absorbed in the vascular to strengthen the lower part of the stem and the fibres of the root, by which it holds its place upon whatever object they have grasped. They bear a dioicous inflorescence with lateral flowers inserted among the leaves, but neither they nor the branches are strictly axillary in Fontinalis as in most other mosses, but are inserted a little higher up than the axillæ of the leaves, and sometimes even at the side of the next leaf above. And here we do not think we can do better than quote a passage from Mr. Wilson; he says :—

"During the development of the fruit, the gemmiform flower is enlarged and elongated, and becomes a perichætial branch, the perichætium being composed of about four spires of imbricated leaves, distinguished from the stem leaves by their larger dimensions and more firm texture, closely applied to the young capsule and torn to shreds as it swells to its full size; they are inserted so high up that the vaginula in this genus seems to be almost wanting as a distinct organ, the upper part of the ramulus serving that office. The curious and extremely beautiful peristome should be examined in a recent state, before the lid is fallen away, in order to see it in perfection. If fine transverse sections of the somewhat unripe fruit are placed under the microscope, the structure of the peristome will be most advantageously exhibited, and its exquisite symmetry will much interest the observer."

We have preferred thus giving the words of another, lest our own should be accused of enthusiasm. The genus derives its name from its aquatic nature.

Fontinalis antipyretica, or the *greater water-moss*, of which we give an illustration, with the fruit, and a stem-leaf, and perichætial leaf magnified, is the frequent inhabitant of our ponds and streams, with stems a foot long or more, and much subdivided, alike carpeting the home of stagnant waters, waving in the mountain streamlet, covering the stones in artificial waterfalls, or dancing in the mill-race; in fine, growing wherever a stone is submersed in pond or lake, and there becoming the abode and the sustenance of numerous paludinæ, etc. The leaves are widely ovate, acuminate, or ovate lanceolate, sharply keeled, almost doubled, or complicate, and with the peculiarity of having all the leaves of the same branch with the margins reflexed on the same side, whether right or left, the other margin being plain. They often split down the

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middle along the keel, and then the half leaves look like the whole leaves of the next species, *F. squamosa*. They are of a yellowish-green when young; olive or lurid green when old; entire or obscurely denticulate at the apex, placed in a trifarious manner upon the stem, and nerveless. The perichætial leaves, as will be seen in the illustration, are obtuse and jagged at the apex.* The capsules are sparingly produced, except on the lower part of the older branches, where they are numerous, each one immersed in its closely-sheathing perichætium, and having the lid alone protruded, till it falls off, when the blood-red peristome appears like a minute circlet, fringing the tip of the little oval bundle formed by the capsule and perichætial envelope. The peristome is double, the outer one consisting of sixteen equidistant, linear-subulate, very long teeth, much trabeculated internally, and cohering at the apex in pairs; the pairs tortuous and incurved when dry, erect below and spreading in the upper half when moist; the inner peristome is a beautifully tesselated cone, coloured like the outer teeth, with sixteen salient angles and the same number of vertical filiform cilia, united together by numerous horizontal cross-bars, and "elegantly studded internally with projecting spurs," the remains of the fractured cellules whose rupture has set it free. The lid is narrowly conical, acute, half as long as the capsule, and wears a calyptra of nearly the same size and shape. The spores are small and greenish.

The name *antipyretica* was given to this species by Linnæus in allusion to its being employed by the Swedes as an "insurance against fire;" for the moss possessing the peculiar property of not being inflammable, they fill up with it the spaces between the chimney and the walls of their houses, by which the both exclude the air and guard against accidents by fire.

There are two varieties of this moss, the one we figure was culled from Longfords Lake, near Avening, in Gloucestershire, in the year 1857. Its stems are red and shining, showing between and through the leaves, their graceful curvatures making the leaves appear somewhat distant. In that lake two varieties grew, as it were, side by side, one more robust, the other more slender, with less complicated leaves, and with fasciculated, not spreading branches.

Fontinalis squamosa, or the *Alpine water-moss*, has still shorter stems, with more crowded, slender, fasciculated branches, and crowded leaves of a dark lurid green, which are

* To the twinkling, twitching movement in the particles of chlorophyll in the cellules of *F. antipyretica*, allusion is made in the May number of this journal, at p. 271. The same molecular motion is often very conspicuous, under the microscope, in the foliage of water, or moisture-loving plants especially, as the *Sphagni*, *Jungermanniæ*, etc., inhabitants of wet and marshy places.

rounded, not keeled at the back as in *antipyretica*, concave and erecto-patent, glossy when dry, lanceolate, or ovate-lanceolate, only half as wide as in the preceding species, nerveless, and entire, but the margin never reflexed, while the perichætial leaves are also narrower, and subserrulate at the apex. The capsule and peristome bear considerable resemblance to those of *F. antipyretica*, from which, however, the plant may always be distinguished by its smaller and concave, not carinate leaves of a lurid green, its more slender stems, and more numerous fasciculate branches. It inhabits mountain rivulets, but is not generally found bearing fruit.

The *bristly water-moss, Dichelyma capillaceum*, is also an inhabitant of Alpine rivulets, but very rarely met with, its only undoubted European haunt seeming to be the province of Westermann, in Sweden, though it was once supposed to have visited Loch Awe. In British North America Mr. Drummond is said to have encountered it in abundance, and we give a brief description of it in hopes that some enterprising Scottish tourist may immortalize his name by drawing it forth from the custody of some Highland loch or streamlet, where its slender stems may be hidden by the multitude of other organisms that are striving for existence within its waters.

Dichelyma, named from διχαω, *to divide*, or *be divided into two parts*, and ἔλυμος, *an envelope* or *covering*, in allusion to the calyptra being cloven, has slender, rather rigid and brittle stems, varying from three to six inches in length, the branches few and widely spreading, either secund or stretching in two directions; with leaves more or less crowded, slightly falcate, erecto-patent, secund, subulato-setaceous, carinate, of a dull green, but glossy when dry, the nerve much excurrent, and forming the upper attenuated portion of the leaf, which never becomes flaccid, scarcely alters in drying, and in allusion to which the term *capillaceum*, or *bristly*, is applied to this species. The areolæ are narrow and elongated, the perichætial leaves very long, convolute, nerveless, and overtop the capsule, which is pedicellate, of thin texture, and shortly oval form, with a wide mouth destitute of annulus, and a conical or rostellate lid, which is large in proportion to the capsule; the peristome also is large, the outer teeth of a tawny red, granulated, almost linear, perforated along the medial line with from twelve to fifteen articulations, but fragile and fugacious; the inner peristome is composed of sixteen still narrower articulated cilia, perforated like the teeth, which however they exceed in length, have from fifteen to twenty joints, are marked with a medial line, papillose, of an orange-red colour, and free except at the summit, where they are united by a few cross-bars. The spores are small, and the inflorescence is dioicous.

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We now turn to

THE HYPNA, OR FEATHER-MOSSES,

a genus so abundant in our isles that, according to some authors, they compose one-fifth of our whole vegetation. They have a lateral fructification, with cernuous curved capsules on long fruit-stalks, bearing a dimidiate calyptra, and having a double peristome; the outer of sixteen equidistant, lanceolate-acuminate teeth, trabeculated on the inner side, reddish-brown or yellowish; the inner peristome is formed of a membrane divided half way down into sixteen carinate processes alternating with the outer teeth, and having intermediate cilia, which are sometimes solitary, sometimes two or three together. The lid is conical, and more or less obliquely rostrate from a hemispherical base.

The species are all perennial, and grow in almost every kind of locality; but vary much in size, in habit, in the mode of vegetation, the form of their leaves, and the position of their flowers. The generic name is derived from *ὕπνος, sleep*, which tells of the use formerly made of it; and even now, a pillow stuffed with dried hypnums is by some thought to promote sleep as much as a pillow of hops. They ripen their capsules chiefly in the winter months; but some come to perfection in the spring, and several during the summer. As space would utterly fail us to notice half the members of this extensive genus, we will restrict ourselves to briefly describing those which fruit during July and August, and making a few remarks upon some others of which we may have anything new to relate, either as to locality, season of fruiting, etc., etc.

Hypnum delicatulum, then, the *delicate feather-moss*, fruiting in July and August, has a pinnatified stem, erect or decumbent, clothed with branched villi, or little green jagged processes, which cover the stem among the leaves, which leaves, in this species, are of a yellowish green, cordate acuminate, somewhat plicate, reflexed in the margin, minutely toothed in the apex, below which the rather broad nerve ceases, beautifully muricated with little sharp prominences all over the back, and even crested with them on the keel. It gives off short attenuated branches, which are often recurved and taking root at the extremity. The perichætial leaves are entire, not fringed, pale, erect, and lanceolate. The fruit-stalk is smooth, of a pale reddish colour, and an inch or more in length; the capsule oblong, curved, of a pale brown, with a conical-acuminate lid half as long as the capsule, and covered by a yellowish calyptra. Its habitats are limestone rocks and chalk hills. We have met with it, in company with *H. tamariscinum*, on the Cotteswold range in Gloucestershire.

This moss has often been confounded with *H. tamariscinum*, but its foliage is of a much paler hue, more closely muricated, more acutely pointed, the capsules of a pale brown instead of purplish red as in *tamariscinum*, and the lid short; whereas in *tamariscinum* it is rostrate, with a long beak. The aspect and season of fruiting, too, are different; *H. tamariscinum* being proliferous with innovations, the lower parts of which, as well as of the stem, are bare of branches, and it ripens its capsules in November.

The ostrich-plume feather-moss, Hypnum Crista-Castrensis, is a large and handsome species, fruiting in July and August, and producing stems from three to four inches in length, closely pectinated with crowded branches, about half an inch long, and slightly recurved. The foliage is yellowish and glossy, the stem-leaves are ovate acuminate, and circinnato-secund; those of the branches lanceolate-acuminate, still more circinnate, distinctly plicate, and having a recurved margin and serrulated apex. The perichætial leaves are erect, but striated. The capsule is of a reddish brown, curved and cernuous, on a fruit-stalk of more than an inch in length, and having a conical pointed lid.

This beautiful moss is a lover of mountainous districts; and, though rare with us, is abundant in the fir forests of Switzerland; it is also found plentifully in some localities in Scotland, near Loch Awe, in Argyleshire; and Ben Voirlich, Hill of Kinnoul, near Perth, Ben Lawers, etc., have been given as its localities, and we have ourselves most unexpectedly met with it on several parts of the Cotteswold range of hills in Gloucestershire.

Another inhabitant of the mountain, where its shining yellow flakes adorn the inclined faces of shady rocks, is the elegant little *Hypnum demissum*, or *prostrate rock-feather-moss*, extensively spreading its prostrate filiform stems, which are weak and flaccid, and all stretch out in one direction without interlacement, and bearing but few branches, which are short, slender, and of a reddish colour. The leaves are elliptic-lanceolate, entire, with a reflexed margin, loosely imbricated, slightly spreading, somewhat secund upwards, and with narrow elongated areolæ. The perichætial leaves are erect and lanceolate; the very slender fruit-stalk is smooth, reddish, and about half an inch in length, bearing the small, horizontally cernuous, pale brown capsule, whose lid has a long slender beak; and the capsule becomes contracted beneath the mouth in drying. Cromagloun Mountain, near the Upper Lake of Killarney, and near Glengariff, Ireland, also near Beddgelert, North Wales, are given as its habitats.

A fruiter in June and July is *Hypnum incurvatum*, or the

incurved feather-moss, which grows in darkish green patches on walls and stones in shady situations, chiefly in limestone districts. It has creeping stems, more or less pinnatified, with depressed branches, which however curve upwards at the top, and the leaves all bend upwards. They are ovate-lanceolate, acuminate, entire, and two-nerved at the base; the capsule is shortly ovate, cernuous, rather small, with a distinct annulus, and a short, acutely-conical lid. The inflorescence is monoicous, and the inner peristome furnished with cilia.

Hypnum pulchellum, the *neat mountain feather-moss*, or, as its distinctive scientific appellation signifies, the *little beauty*, has also a monoicous inflorescence, and ripens its capsules in June and July. It may be found on shady rocks in hilly districts, and at the roots of trees by rivulets, where its tiny branches, scarcely half an inch long, usually compressed, crowded, fastigiate, and more or less erect, form dense green glossy tufts, with leaves almost distichous, or two-ranked, but rather crowded and assurgent, gradually tapering from the base to an acute point; entire and usually nerveless. The perichætial leaves are erect; the reddish fruit-stalk not an inch long, and inserted near the base of the fertile branch among the roots; its capsule oblong, curved, of a pale brown, suberect, with a short, yellowish, conical pointed lid; tapering into the fruit-stalk at the base, and contracted below the mouth when dry.

Hypnum Mühlenbeckii, *Mühlenbeck's Alpine feather-moss*, inhabits Alpine rocks, fruits in July, and grows in dense green tufts, which are glossy when dry, half an inch or less in height, suberect and brittle, with fasciculate drooping branches a quarter of an inch long; the leaves subcomplanate, subcordate, acuminate, evidently serrulate, of firm texture, and either nerveless, or faintly two-nerved at the base. The fruit-stalk is reddish, less than an inch long, and the capsule, which is at first yellowish, ripens into a pale brown, is oblong in form, tapering at the base, somewhat inclined, slightly curved, striated when dry, and covered with a short conical lid. The inflorescence is monoicous.

In woods, on hedge-banks, and in moist rocky places, may be found the prostrate, sparingly-branched stems of *Hypnum denticulatum*, or the *sharp flat-leaved feather-moss*, which fruits during the summer, and has subfasciculate branches arising from the base of the stem, whence also the fructification proceeds; the leaves are complanate, glossy, of a light green, obliquely ovate, acuminate, two-nerved at the base, the lower half of the margin recurved, sometimes serrulate at the apex; the fruit-stalk is about an inch long, reddish, and the capsule, more or less tinged with red, has an acutely conical, but not a

beaked lid; the outer teeth are reddish brown, and the inflorescence is monoicous.

On Ben Lawers, the favourite haunt of some of our rarer mosses, may be found fruiting in August, the rare species, *Hypnum Halleri, Haller's feather-moss.* It, too, has a creeping stem and monoicous inflorescence, but grows in dense brownish patches, with short erect branches, crowded towards the interior of the tuft, the leaves crowded and much recurved, roundish ovate, shortly acuminate, minutely denticulated, slightly reflexed at or near the basal margin, sometimes nerveless, sometimes two-nerved at the base, the areolæ oblong and uniform, somewhat larger than in *H. polymorphum,* which this species resembles in size. The fruit-stalk is above half an inch in length, with erect perichætial leaves and a curved cernuous capsule, covered by a yellow, bluntish conical lid.

Hypnum polymorphum, or the *dwarf starry feather-moss,* is one of the smaller kinds not generally distributed, but forming the minute adornment of walls, rocks, and banks in limestone districts. It was found near Edinburgh, by Dr. Greville; on declivities near the Menai quarries, by Mr. Wilson; on limestone rocks, near Castle Howard, in Yorkshire, and on the ruins of Kirkham Abbey, by Mr. Spruce; and we have repeatedly met with it, richly fruited, in various localities in Gloucestershire. It ripens its capsules in May and early in June, but we mention it here because, as far as we know, Gloucestershire has not yet been named as possessing it, though it grows, freely fruiting, in two or three places on the Cleeve Hill, about three or four miles from Cheltenham, and also in the neighbourhood of Minchinhampton, beyond Stroud.

It has a procumbent stem, with simple slender erect branches, with rather crowded spreading leaves, somewhat squarrose, but secund, cordate, or ovate-lanceolate; in some of the leaves rather suddenly, and in all much acuminated, entire and nerveless. The capsule is oblong, curved and cernuous, with a conical lid, and the inflorescence is monoicous.

Hypnum plicatum, or the *plaited feather-moss,* too, we met with on the 23rd of April, this year, on the side of a stone wall, and near its base, at the summit of Leckhampton Hill, overlooking the valley of the Severn. There was a quantity of the moss, but only one solitary capsule, and that over-ripe, so that it had lost both calyptra and lid. It has procumbent, irregularly branching stems, the branches incurved, elongated, and ascending; the stem tomentose, with short branched leafy processes; the leaves imbricated, almost appressed in the dry state, yellowish, rather glossy, ovate, much acuminated, or tapering, more or less secund, and plicate, with narrow elongated areolæ; the perichætial leaves are pale and glossy,

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smooth and erect, but slightly recurved at the apex; the fruit-stalk slender, smooth, reddish, scarcely half an inch long, and bearing a small, ovate-oblong, dull reddish-brown capsule; the peristome pale yellowish, and, probably from being over-ripe, imperfect; but the presence of this one capsule is sufficient to establish the hitherto doubtful season of fruiting, which we are inclined to fix for the end of February or early in April; and the lofty head of Ben Lawers, in Perthshire, can no longer claim to be the only British nurse of the species.

On the authority of Dr. Beach, Leckhampton Hill also possesses near its summit *Cylindrothecium Montagnei*, *Montagne's cylinder-moss*, another of the pleurocarps, for which Ben Lawers is famed. And, on the same authority, *Climacium dendroides*, Hooker and Taylor's *Hypnum dendroides*, the *marsh tree-moss*, is to be found in a marsh at Puckham Scrubs, about four or five miles from Cheltenham. This species was named Climacium by Weber and Mohr, from κλίμαξ, a *stair* or *ladder*, in allusion to the barred appearance of the inner peristome; not only in its tree-like aspect, but in several other particulars it differs from the Hypnums proper.

The shrubby *Thamnium*, or *Isothecium alopecurum*, the *fox-tail frond-moss*, with its miniature tree-like form, and dendroid stem, naked below, may be found in Gloucestershire, but in vain shall we look there for the capsules, either in October, as given by Hooker, or in November, as given by Wilson, for its fruiting season; the writer, however, met with some square yards of ground at the foot of a fir-tree grove, at the head of Longfords Lake, near Avening, covered with it in luxuriant profusion, and freely fruiting, January the 21st, 1858, some specimens having twenty-five and more capsules, some of them having their oblique long-beaked lids still on, while others had dropped their lids, and were exhibiting their pale double peristome, very like that of a Hypnum, to which genus it was formerly assigned by Linnæus and others, but from which it has been very properly separated on account of striking differences.

Space will not admit of further details, but we trust that those of our readers who have followed us thus far, will be induced to enlarge the sphere of their pleasures by investigating for themselves this too-neglected department of nature's economy.

FACTS ABOUT IRON.

ANTIQUARIES have, for the most part, decided that an "age of bronze" preceded an age of iron; but, although they may establish their theory to a certain extent, it cannot be accepted as universally or necessarily true, and it is very important, in studying the manners of ancient races, or in examining their works, to bear in mind the arguments that favour an hypothesis of a totally opposite kind. When rich ores are readily attainable, and wood to make charcoal is at hand, the most natural order of development is that iron should be smelted and employed long before the discovery of the mode of making bronze; and if any people, who might have extracted iron with facility, really began their metal working by a scientific combination of copper and tin, it would be only fair to conclude that they did so, not as a result of native development, but by the instruction and example of a more advanced race. Dr. Percy remarks,* "that of all metallurgical processes the extraction of iron is the most simple. Thus, if a lump of red or brown hematite be heated for a few hours in a charcoal fire, well surrounded by or imbedded in the fuel, it will be more or less completely reduced, so as to admit of its being forged at a red heat into a bar of iron." He adds that this primitive process requires far less skill than what is employed in the manufacture of bronze. The extraction of iron from its richer ores belongs to an antiquity transcending the historic period, and it is remarkable that it can be effected on a small scale without even the help of a furnace, in a simple apparatus rather partaking of the character of a forge. Dr. Percy cites an example of this, upon the authority of Dr. Hooker, in whose *Himalayan Journal* appears an elegant sketch of a young man standing upon a large pair of primitive bellows, which he works with his feet. A fascinating young woman stands behind him upon the same machine, and the stream of air they impel passes through the bottom of an upright, flat, sloping stone, under whose shelter glows a small fire, in which little balls of iron are produced. This sketch is copied in Dr. Percy's work.

In working on a small scale, malleable iron is obtained directly from suitable ores. This is the case in the native production of the Hindoos, the Africans, the Borneans, and all

* *Metallurgy: the art of Extracting Metals from their Ores, and adapting them to various purposes of Manufacture*, by John Percy, M.D., F.R.S., Lecturer on Metallurgy at the Royal School of Mines. Iron and Steel with Illustrations, chiefly from original drawings, carefully laid down to scale. *Murray.*

other iron-working races in an early stage of metallurgical knowledge. In the enormous works of modern times the result of smelting is to obtain cast iron, which requires separate and costly processes to bring it into the malleable state. Ultimately, however, we may expect the success of plans by which malleable iron may be obtained directly from the ore, in quantities and at prices adapted to manufacturing requirements. Those who desire to know what has been done in this direction may consult Dr. Percy's elaborate work. It is not a subject that we intend to discuss in this paper, but we cannot help remarking that iron production, under our cumbrous patent laws, has got into such a deplorable state of complexity and confusion as to indicate a necessity, both in the interest of the public and that of inventors, to reconsider our whole system of offering the alleged advantages of a monopoly to the discoverers of new processes and new plans. So far as the general public is concerned, there is little doubt that our patent laws act badly; but it is obviously unfair that inventive talent should go without its reward, and it does not coincide with ordinary ideas of justice that the anxious toil and laborious thought of many years should be seized upon by outsiders at the very moment when a reasonable prospect of remuneration appears. Thus, at first sight, patents as granted in this country seem advantageous to inventors; but it will be found that a time arrives in most important branches of manufacture in which this ceases to be the case. Let any one, for example, now turn his attention to iron, and he will find the patents already in existence surrounding him like pitfalls on every side. Schemes unsuccessful, and schemes partially successful by the hundred are found to be under the protection of the patent laws. Very often it is quite impossible to ascertain the limits to any particular patent without a series of actions and appeals, in which the longest purse is most likely to win. Thus, a fresh comer into the field buys "a pig in a poke" when he purchases a patent, and has small chance of peaceably enjoying his acquisition, unless it should prove worthless; and little hope of maintaining it against attack, unless he has a great capital at his command. We must still come back to the moral axiom that those who benefit society by their intelligence deserve reward, but we much doubt whether anything like our existing patent system is calculated to secure that desirable end.

In this country iron working was probably an ancient art, as there is evidence that it was practised anterior to Roman times. Dr. Percy cites authorities to show that it was understood by the old Egyptians—Mr. Layard found some iron work at Nineveh, and Mr. Francis Galton has recently given to

Dr. Percy a specimen of black slag, not unlike iron slag, lately found in "very ancient Sinaitic remains, conjectured to be anterior to the time of Moses."

Many of the iron ores now worked in this and other countries would not have suited the early processes, nor would they, in many cases, have disclosed their character to the imperfect science of early times; but, notwithstanding this fact, which would operate in favour of bronze in certain localities, it still remains for the antiquary to explain why nations who were acquainted with iron should have resorted to an expensive and, as we should think, imperfect substitute for a metal that we now regard as a prime necessity of civilized life.

Of all the substances which modify the character of iron, carbon is the most important, enabling it, according to circumstances and treatment, to become hard, elastic, or brittle. The mode of the existence of carbon in its compounds with iron is by no means well understood. Dr. Percy states that it is partly determined by the conditions under which the metal is heated and cooled, at temperatures very far below its melting point; and he adds that, "Professor Abel, of the Arsenal, experimented on this point a few years ago, and found that hardened steel wire dissolved in hydrochloric acid without residue; whereas the same steel in the softened state yields by such action a dark flocculent carbonaceous residue when acted upon by the same acid." Steel, in its three states known as "blistered," "tilted," and "hardened," yields a different residue or solution. It seems, on the whole, to be proved that carbon may exist in iron in the state of mechanical diffusion, and also in a state of chemical combination; but neither Percy nor any other chemist has succeeded in throwing much light upon the carbides of the metal. It is very curious that hammering should affect steel so as to change the proportion of its carbonaceous residue in acids, but "Caron found that rolled steels, *cæteris paribus*, yielded a larger amount of carbonaceous residue than hammered steels." In this case the mechanical force exerted in hammering seems to have passed into the state of a chemical force, by which the condition of the carbon was changed. Rolling, as a less disturbing action of mechanical force than hammering, produced less effect.

Dr. Percy, though fully believing in the influence of mechanical force as just described, throws some doubt on the amount of action usually ascribed to blows or vibrations in rendering iron brittle, and he is not satisfied that it induces a crystalline structure. As this question enters so largely into safety of railway travelling, it is hoped that it will receive thorough investigation. Pending this, we may remark that the

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condition of iron after fracture must not be taken as necessarily showing in what state it existed before fracture occurred. Dr. Percy tells us that "when a piece of iron which has been melted, and which is largely crystalline, is cautiously hammered at a suitable temperature into a shape adapted for rolling, and then rolled into a bar, not too thick, it will present either a fibrous or a crystalline fracture, according to the manner of breaking it, and especially the duration of the act. After nicking it to a slight depth on one side with a cold chisel, and then bending it slowly backwards from the line of the nick, the fracture will be highly fibrous, and may be almost silky. On the other hand, if it be nicked all round, and suddenly broken in the line of the nick, the fracture will be crystalline, with, it may be, only here and there an indication of fibre."

We have stated that the modern processes for smelting iron on a large scale produce cast, or carburized iron, and this will be readily understood from Dr. Percy's explanations. "The furnace being in operation, or, as it is technically termed, in blast, iron-yielding materials (of which the essential part is oxide of iron), flux (generally limestone), and fuel, are continually thrown in at the top, so that the interior may be kept filled up nearly to the filling holes, while slag, or "cinder," and cast iron continually accumulate in the hearth at the bottom, the former flowing out over the dam, and the latter being allowed to escape at intervals through the tapping hole." The oxygen of the air blown in to constitute the blast forms carbonic acid with the carbon of the fuel, and this gas, passing into the state of carbonic oxide, readily reduces the oxide of iron. The ore, or iron oxide, is reduced as it descends in the furnace, and as it falls towards the lower and hottest part of the furnace the metal "becomes carbonized, and converted into cast iron, which trickles down in a molten state to the bottom." The iron not only acquires a large dose of carbon in this process, but likewise takes up all kinds of impurities that are present, and thus needs subsequent treatment to decarbonize it, and remove extraneous matters. An expensive and very laborious treatment of cast iron is resorted to in our large works for the purpose of obtaining the metal in a malleable state. This is technically called "puddling," and "consists essentially in stirring about pig-iron molten on the bed of a reverberatory furnace, heated by flame, until it becomes converted into malleable iron, through the decarbonizing action of the oxygen of the air circulating through such a furnace." One of the most remarkable inventions for decarbonizing pig-iron is that of Mr. Bessemer. The pig-iron is melted in a suitable furnace, and jets of air are then introduced. As the inventor states, "the air expanding in volume, divides itself into glo-

bules, or bursts violently upwards, carrying with it some hundred weight of the fluid metal, which again falls into the boiling mass below. Every part of the apparatus trembles under the violent agitation thus produced, a roaring flame rushes from the mouth of the vessel, and as the process advances it changes its violet colour to orange, and finally to a voluminous pure white flame. The sparks, which were at first large, like those of ordinary foundry iron, change to small hissing points, and these gradually give way to soft floating specks of bluish light as the state of malleable iron is approached."

As our object is not to write a technical paper on iron manufacture, we shall refer those who want detailed information on the various projects of the day, to Dr. Percy's work, merely citing his opinion that for the Bessemer process to be "generally applicable in this country, it must be supplemented by the discovery of a method of producing pig-iron, sensibly free from sulphur and phosphorus, with the fuel and ores which are now so extensively employed in our blast furnaces." The doctor adds, "the problem may be difficult of solution, but surely it is not a hopeless one."

In our domestic economy, broken cast-iron vessels are usually thrown away; but the Chinese not only make very thin cooking utensils of the cast metal, but dexterously mend holes and cracks.

Dr. Percy states, on the authority of Dr. Lockhart, how this is done. The Chinese tinker scrapes the surface of the broken vessel clean. He then melts a portion of cast iron in a crucible the size of a thimble in a furnace "about as large as the lower half of a common tumbler." The iron when melted is dropped on a piece of felt covered with charcoal ashes. It is pressed inside the vessel against the hole to be filled up, and as it exudes on the other side, he strikes it with a small roll of felt covered with ashes. The new iron and the old adhere, and when the superfluous metal is removed, the job is complete.

Among the miscellaneous matters of interest in Dr. Percy's book, not the least curious are those relating to the action of sea-water on cast iron, converting it at length into a grey porous mass that grows rapidly hot in contact with air. In 1740 some iron guns that went to the bottom with part of the Spanish Armada, were fished up near Mull, in Scotland. On scraping them they soon became so hot that they could not be touched, and a ship surgeon, who was applied to for an elucidation of the mystery, suggested that "as they went down in the heat of action they might not have had time to cool, though nearly 200 years had elapsed."

The alloys of iron are numerous, and special merits are

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claimed for many of them. On this subject, however, much information is still wanted, and when fine steel is produced, it by no means follows that it owes its qualities to a minute portion of some other metal, or non-metallic substance conjectured to have affected it beneficially. It is of course quite possible that minute additions may produce great results; but if we may judge from Dr. Percy's book, very little has been accurately ascertained. One alloy of 80 parts zinc, 10 copper, and 10 iron, is said to possess very valuable working properties, and not to rust in moist air.

Dr. Percy also mentions Mr. Eckman's process of case-hardening by arsenic. Rasped leather, or other nitrogenous animal matter, is made into a sort of porridge with hydrochloric acid and arsenious acid. The metal is painted over with this composition about one-sixteenth of an inch thick, and then heated in a muffle to bright redness. A white surface of arsenide of iron is thus obtained, which effectually resists rust.

The bulky volume from which we have made the preceding extracts forms the second part of Dr. Percy's *Metallurgy*, and a third part is expected to complete it. The scientific world will unanimously applaud the doctor's labours. He has brought together an amazing mass of facts, which perhaps no one else had accumulated, and a large portion of which he has for the first time made accessible. He has undoubtedly achieved a great work; but the second volume, like the first, leaves the regret that his talent for exposition and arrangement is not equal to his enormous metallurgical learning. As storehouses of facts, the two volumes are invaluable, but as regards the elucidation of principles, or convenience for reference, they leave much to be desired.

THE REMARKABLE WEATHER OF THE EARLY SUMMER OF 1864, AT THE HIGHFIELD HOUSE OBSERVATORY.

BY E. J. LOWE, ESQ., F.R.A.S., ETC.

THE extraordinary heat of May and the equally extraordinary cold of June makes it desirable to place on record this singular weather of 1864.

On referring back to old records we find that on Midsummer day, A.D. 1035, so vehement a frost occurred that the crops and fruit were destroyed; that on the 2nd of May, 1767, at Aldstone and Cole Fall, there was a great fall of snow and hail, the ground being covered in some places to the depth of three feet. In this year (1767), on July 13th, there were great floods in Bedfordshire and Lincolnshire; on July 4th a prodigious quantity of snow fell in Pomerania; on August 5th a great storm occurred in Roxburgh, carrying houses and bridges away; on August 12th, at Leeds, the river rose six feet in an hour, being higher than for twenty years, and destroying forty bridges; that during the month of May, on the 12th, a dreadful thunder and hail-storm passed over County Fermanagh; another on the 16th at Earlstown, Scotland, the hail being four inches in circumference, and on 31st, a third, occurring at Nottingham, Norwich, and London, accompanied by a N.W. gale. In Herefordshire there were fewer apples than for twenty years previously, and scarcely any walnuts.

In 1773, on May 6th, at Birmingham, snow fell to the depth of twelve inches, followed, from the 18th to the 27th, by the highest floods ever known in May, and which were general throughout England. Earthquakes occurring in Staffordshire and Shropshire on the 30th of June and 1st and 2nd of July.

In 1780, at Nottingham, on May 20th, a severe frost; on the 28th the temperature 75° in shade, on the 29th 81°, and on the 30th only 57°.

In 1794 the greatest heat and the greatest cold began to be recorded at the Royal Society, and in 1840 at the Royal Observatory, so that for the last seventy years we have a continuous series of observations, and from others of Dr. Dalton, Mr. Luke Howard, and Mr. Bent, the series can be extended back to 1785; and a descriptive history as early as 1752, or for 113 years, and in no instance has the temperature of the 18th and 19th May, 1864, been reached, nor the cold of June 1st, 1864.

In order to compare the observations, we will select Man-

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chester (Mr. G. V. Vernon), the Royal Observatory, and Highfield House.

Comparison of the greatest heat at the Royal Observatory, the Highfield House Observatory, and at Manchester, between 1856 and 1862, in May and June:—

Year.	Royal Observatory.		Highfield House Observatory.		Manchester.	
	May.	June.	May.	June.	May.	June.
	°	°	°	°	°	°
1850	76·5	85·1	79·2	87·2	—	78·0
1851	74·2	87·0	77·0	85·3	75·0	—
1852	73·4	72·7	79·0	77·0	73·0	76·5
1853	78·8	81·0	82·0	82·0	77·7	79·0
1854	70·5	78·5	73·0	79·0	72·0	77·0
1855	81·5	83·5	81·9	83·3	84·0	83·5
1856	72·0	83·1	70·8	84·2	78·3	77·0
1857	80·2	92·7	72·8	88·0	77·8	90·5
1858	81·2	94·5	84·0	92·2	—	91·2
1859	77·0	81·3	78·5	80·4	82·0	81·8
1860	76·5	74·0	79·8	73·5	78·0	71·4
1861	80·2	81·8	79·8	82·8	72·2	84·0
1862	81·5	73·5	77·7	76·4	76·0	—

In the above years it will be seen that the maximum heat in May reached 81°·5 at the Royal Observatory, and 84°·0 at Highfield House and Manchester; and in June, 94°·5 at the Royal Observatory, 92°·2 at Highfield House, and 91°·2 at Manchester. In May it was warmer at Highfield House than at Manchester from 1851 to 1854, colder from 1855 to 1859, and warmer from 1860 to 1862; at the Royal Observatory it was colder from 1850 to 1855, warmer in 1856 and 1857, colder in 1858 to 1860, and warmer in 1861 and 1862.

In June it was warmer at Highfield House than at Manchester, except in the years 1855, 1857, 1859, and 1861; it was warmer at the Royal Observatory, except in 1850, 1852, 1853, 1854, 1856, 1861, and 1862.

The mean of the greatest heat of all these years being:—

Greenwich . . .	77°·2	in May, and	82°·2 in June.
Highfield House .	78·1	,,	82·4 ,,
Manchester . . .	76·9	,,	80·9 ,,

Highfield House being warmer than Greenwich in May by 0°·9, and in June by 0°·2, and warmer than Manchester in May by 1°·2, and in June by 1°·5.

Comparison of the greatest cold at the Royal Observatory, the Highfield House Observatory, and at Manchester, between 1850 and 1862, in May and June:—

Year.	May. Royal Observatory.	May. Highfield House.	May. Manchester.	June. Royal Obs.	June. Highfield House.	June. Manchester.
	°	°	°	°	°	°
1850	31·7	31·2	—	36·2	35·1	—
1851	33·5	31·0	36·0	38·5	38·0	—
1852	29·3	32·0	30·0	41·0	39·7	38·0
1853	32·6	30·4	30·0	39·9	37·2	40·0
1854	34·8	31·4	31·5	41·4	41·0	42·0
1855	28·3	26·8	24·0	39·3	39·8	38·5
1856	29·8	30·9	28·8	41·1	39·1	39·0
1857	31·5	30·0	30·0	38·8	40·0	43·8
1858	32·1	30·9	—	45·3	39·5	41·8
1859	33·1	30·8	30·8	43·5	41·9	44·7
1860	32·5	30·0	33·0	43·5	39·5	40·8
1861	33·4	28·7	28·0	42·9	42·5	44·0
1862	37·8	35·5	38·0	43·4	39·7	—

In these years Highfield House was colder than at the Royal Observatory in May in all years, except in 1852 and 1856; and in June, except in 1855 and 1857. Highfield House was colder than Manchester in May, except in 1852, 1853, 1855, 1856, and 1861; and in June, except in 1852, 1855, and 1856.

The mean of greatest cold in all these years gives the following result:—

Greenwich . . .	32°·3	in May, and	41°·1	in June.
Highfield House .	30·7	„	39·5	„
Manchester . . .	30·9	„	41·3	„

Highfield House being colder than Greenwich in May by 1°·6, and in June by 1°·6; and colder than Manchester in May by 0°·2, and in June by 1°·8

From the Royal Society and Royal Observatory Records.

The highest readings in May, and greatest cold in May and June, with the maximum heat in June of those years:—

Year.	Greatest Heat in May.	Greatest Cold. May.	Greatest Cold. June.	Greatest Heat. June.
	°	°	°	°
1795	81·5	36·0	41·0	77·5
1807	84·0	44·0	48·0	77·0
1808	82·0	42·0	48·0	76·0
1833	81·4	43·4	46·6	80·8
1841	82·8	41·2	40·3	78·5
1846	84·3	38·3	49·4	91·1
1847	86·2	36·0	41·0	80·4
1848	83·0	33·5	38·7	78·4
1855	81·5	28·3	39·3	83·5
1857	80·2	31·5	38·8	92·7
1858	81·2	32·1	45·3	94·5
1861	80·2	33·4	42·9	81·8
1862	81·5	37·8	43·4	73·5

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From 1785 to 1807, Mr. William Bent kept a register in London, during which time the thermometer never reached 80° in May, except in 1807.

Dr. Dalton's observations at Kendal only give once a temperature of 80° in May, which occurred in 1788.

My late lamented friend, Mr. Luke Howard, in his series of observations from 1797 to 1832, made at Plaistow and Tottenham, near London, gives the following:—

1806,	May	29	.	.	.	.	.	.	81°
1807,	„	25	.	.	.	.	.	.	85
1809,	„	18	.	.	.	.	.	.	80
1811,	„	26	.	.	.	.	.	.	84
1815,	„	26	.	.	.	.	.	.	80
1822,	„	20 and 21	.	.	.	.	.		81
1825,	„	23	.	.	.	.	.	.	80
1829,	„	23	.	.	.	.	.	.	81
1830,	„	7	.	.	.	.	.	.	81

In Mr. Glaisher's valuable tables of the mean temperature of every day in the year, based on forty-three years' observations, we have—

May	1	to	3,	mean	50°·0	to	50°·9
„	4	„	14,	„	51·3	„	51·8
„	15	„	17,	„	52·2	„	52·8
„	18	„	21,	„	53·1	„	53·8
„	22	„	27,	„	54·1	„	54·9
„	28	„	31,	„	55·2	„	56·1
June	1	„	3,	„	56·4	„	56·8

The mean temperature of the coldest day in May was 36°·2 on the 3rd, in 1832; the mean temperature of the hottest day in May was 72°·6 on the 15th in 1833, giving a range of 36°·2 in mean temperature.

The mean temperature of the coldest day in June was 45°·0 on the 7th in 1814; the mean temperature of the hottest day in June was 76°·1 on the 13th in 1818, giving a range of 31°·1 in mean temperature.

In 1864 at Highfield House the mean temperature exceeded the average on every day up to the 22nd, except on the 4th and 9th, on the warmest days being:—

May	14	.	.	.	.	61°·5
„	15	.	.	.	.	68·8
„	16	.	.	.	.	69·2
„	17	.	.	.	.	65·1
„	18	.	.	.	.	72·9
„	19	.	.	.	.	71·2
„	20	.	.	.	.	67·2

Again—

May 26	46°·5
„ 31	47·9
June 1	49·5

Frosts occurred on May	24,	27°·3	on grass, and	34°·9	at 4 feet
„	„	27, 24·9	„	33·9	„
„	„	30, 31·5	„	39·0	„
„	June	1, 23·3	„	30·5	„
„	„	2, 23·5	„	34·3	„

The maximum heat in shade, and greatest cold, in 1864, was—

On May	14, 75°·2,	greatest cold,	40°·9
„	15, 81·2,	„	55·7
„	16, 82·8,	„	56·1
„	17, 80·3,	„	49·8
„	18, 87·7,	„	53·7
„	19, 89·3,	„	56·2
„	20, 80·7,	„	53·5
„	21, 65·7,	„	50·7

At Highfield House the greatest heat of May from 1842 to 1864 has been—

1846	81°·4
1847	84·5
1848	83·0
1853	82·0
1855	81·9
1858	84·0
1864	89·3

So that our greatest heat in 1864 has exceeded every year in May by 3°·1; and, were we to carry our investigations through the months of June, July, and August, we should find very few days in these hotter months in which the temperature rose above 89°·3.

It is worthy of remark that almost invariably hot weather in May has been followed by violent atmospheric disturbances, such as thunder-storms, hail-storms, gales, and floods, and even not infrequently by earthquakes and disturbances of the sea.

Taking the thirteen hottest years in May from 1794 to 1862, as recorded by the Royal Society and Royal Observatory, it will be seen that, in eight years the temperature never rose to the same height again during the summer, whilst in 1846, 1857, and 1858 it became very hot.

As a contrast to the great heat of May, 1864, we will turn

to the great cold of the 1st of June, 1864, in the neighbourhood of Nottingham (at 4 feet elevation), viz.:—

Highfield House Observatory, greatest cold	30°·5
Beeston Observatory . . . „	28·5
Lenton Grove (Mr. Samuel Morley),, .	27·5
Highfield House, greatest cold on grass .	23·2
Beeston . . . „ „ .	23·3

This frost was much more severe in the valley a quarter of a mile from both Highfield House and Beeston, Mr. Morley's instruments being half-way between these two observatories.

The damage done at Highfield House is confined to the leaves of gourds and partial destruction of leaves of potatoes, and French and Kidney beans. At Mr. Morley's, young shoots of hollies and walnuts were killed, and more damage done to beans and potatoes. At Beeston, except in sheltered places, the potatoes and beans were cut to the ground; young shoots of ash trees killed, as well the small branches of Rose Gloire de Dijon, Polygonum Sieboldtii, Rhododendrons, and partial damage to the bloom of strawberries and the fruit of apples, pears, and gooseberries. Much greater damage was done six miles north of this place, at Basford and Bulwell, and where the thermometer must have been considerably lower. Here in every direction beans and potatoes were killed to the ground, every leaf of the walnut destroyed; nearly all the apples, pears, plums, nuts, and gooseberries, the young shoots of hollies, and even those of the English oak.

In referring to the same records of the Royal Society and Royal Observatory as examined by Mr. Glaisher, we obtain the following as the coldest years in June:—

1797 . . .	greatest cold,	40°·0
1802 . . .	„ „	40·0
1841 . . .	„ „	40·3
1848 . . .	„ „	38·7
1849 . . .	„ „	38·6
1850 . . .	„ „	36·2
1851 . . .	„ „	38·5
1853 . . .	„ „	39·9
1855 . . .	„ „	39·3
1857 . . .	„ „	38·8

My own observations at Highfield House giving—

1843 . . .	greatest cold,	40°·0
1848 . . .	„ „	40·1
1849 . . .	„ „	35·3
1850 . . .	„ „	35·1
1851 . . .	„ „	38·0

1852	greatest cold,	39·7
1853	„ „	37·2
1855	„ „	39·8
1856	„ „	39·1
1857	„ „	40·0
1858	„ „	39·5
1860	„ „	39·5
1862	„ „	39·7
1864	„ „	30·5

So that the temperature on the 1st of June, 1864 was 4°·6 lower than had been recorded before in June since 1797, and there is no year nearly so low, even if we go back to 1785; whilst, if we take Mr. Morley's reading of 27°·5, which is quite correct (made by an excellent thermometer of Messrs. Negretti and Zambra, compared by my Kew standard), we have 7°·6 below any other reading, and 8°·7 below the lowest reading in London.

In conclusion, a few words on the weather of May will have its bearings on the subject.

The movement of the wind from the 1st to the 21st was—

From 1st to	5th, direct,	1260°;	retrograde,	1012°
„ 6th to	10, „	635°;	„	472°
„ 11th to	15, „	1720°;	„	1384°
„ 16th to	20, „	3275°;	„	2407°

The direct exceeding the retrograde movement by 1611°, or by 4½ complete revolutions. The greatest changes occurring on the 15th; direct, 956°, retrograde 888°; on the 18th, direct 990°, retrograde 922°, and on the 20th, direct 1440°, retrograde 675.

On the 19th, a few minutes before the time of greatest heat, viz., 2·30 p.m., the thermometrical and hygrometrical conditions of the air were—

Temperature in shade	89°·0
Wet bulb thermometer	67·9
Temperature of the dew point	53·1

Elastic force of vapour, 0·404 of an inch.

Weight of vapour in a cubic foot of air, 4·2 grains.

Additional weight of vapour required to saturate a cubic foot of air, 10·2 grains.

Degree of humidity (100 = saturation) 29.

Weight of a cubic foot of air, 508·8 grains.

Weight of the barometer reduced to the sea-level, 30·204 inches.

Pressure of the gases of the air, 29·800 inches.

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Whole amount of water in a vertical column of the atmosphere, 5·6 inches.

Thunder was heard all the afternoon, and a thunderstorm occurred on the afternoon of the 20th.

On the evening of the 29th the earthquake pendulum showed a sensible movement of the earth from WNW. to ESE., and that from this time till noon on the 30th the earth was in constant gentle movement.

Rain only fell on nine days in May, the amount being only 1¼ inches, the barometer ranging between 29·7 and 30·2 inches.

From the 13th to the 20th there was scarcely any ozone, and during this period an almost cloudless sky.

MAGNUS ON THE CONDENSATION OF VAPOURS.

The *Archives des Sciences*, No. 77, and *Poggendorf's Annalen*, cxxi., p. 174, contain an account of some important researches of M. Magnus on the condensation of vapours on the surface of solid bodies, from which we extract the leading facts:—

M. Magnus begins by referring to a former paper, in which he showed that a thermo-electric pile grows warmer when moist air is brought into contact with its surface, and grows cooler under a similar contact with dry air. These effects are produced whether the surface of the instrument is blackened with smoke, or is kept bright. He considered that the elevation of temperature was due to the latent heat evolved by the vapour during condensation. Pursuing the investigation in a manner that is detailed in the publications to which we have referred, the conclusion was arrived at that all substances grew warmer when brought into contact with air more moist than that which surrounds them, and became cooler in contact with air that is more dry. In order, however, to enable this action to become sensible, the plates must not be too thick. The degree of disturbance varies with the nature of the plates employed, with the dimensions of their surfaces, and with their thickness; but the effects are universal, whether the surfaces be rough or smooth. In employing glass the strongest effect was noticed when the plates were very thin, such as are used for microscopic objects or for polarizing piles. Experiments were made with brass, glass, gypsum, mica, sal gemmi, and alum. When ungreased leather, wood, ivory, gutta percha, and certain other substances were

employed, the deviation of the galvanometer was at least as great, and sometimes greater than when the dry or moist air impinged directly on the thermo-electric pile, showing that they condense vapours more readily than the surface of the pile.

M. Magnus arranged a delicate air thermometer, so that each bulb was surrounded by a small vessel of glass, each glass vessel having a tube proceeding from its neck, immediately over the bulb. On blowing air into one of the glass vessels the thermometer was not affected; but if the air was first dried, then the opposite bulb experienced a cooling action, and became warmer when air saturated with vapour was introduced. The effect was sufficient to produce four to six millimetres difference in the level of the two limbs of the thermometer.

A mercurial thermometer divided into half degrees, and sheltered from currents of air, showed under similar circumstances an effect from 0·2 to 0·3 C.; and, when the bulb was blackened, the variation reached 0·6 C.

The rapidity of the effect depends on the thickness and condensing power of the plates. Sal gemmi and other diathermic bodies were instantaneously affected; metallic plates, etc., varied according to their conducting power.

In giving a summary of results, M. Magnus states that different substances, organic and inorganic, wax, paraffin, glass, quartz, mica, gypsum, various salts, metals rough or polished, and also varnished, condense on their surface vapour from the air in which they are placed, and whose temperature is the same as their own. This condensation has a heating action; and if drier air is introduced, a portion of the liquid that has been condensed evaporates, and cold is the result. Vapours of alcohol, ether, and other substances produced effects analogous to those of water. In general it may be affirmed that vapours are condensed on solid masses to an extent sufficient to produce appreciable changes of temperature. From this it will appear that on every solid surface a layer of vapour always exists, which becomes greater or less, according to the humidity of the air. M. Magnus adds that it cannot be doubted that this film of vapour plays an important part in many actions that occur on the surface of bodies.

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SOLAR OBSERVATION.—COLOURS OF STARS.—CONSTITUTION OF NEBULÆ.—TRANSITS OF JUPITER'S SATELLITES.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

In a previous paper we enumerated several modes of eliminating the superfluous light and heat otherwise so prejudicial in examining the sun. Two very efficient ones, however, remain to be described.

One very generally applicable contrivance is a modification of the diagonal eye-piece, which has been long in use, in order to avoid the neck-twisting process of observation with an achromatic at great altitudes. For this purpose a plane speculum is introduced diagonally into the interior of the eye-piece, or preferably into the tube just beyond the eye-piece; and in the latter form, if a piece of unsilvered glass is used instead of speculum metal, it is obvious that so little light will be reflected from its anterior surface, that a very pale screen-glass will be quite sufficient. Sir J. Herschel, the inventor of this plan, employed it with a Newtonian reflector at the Cape, and Dawes applied it to the achromatic immediately afterwards. The reflection from the second surface must be got rid of, to avoid the doubling of the image. This may be effected by roughening the back, or by using a prism—a modification adopted by Cooke with his large achromatics. The end of the tube, behind the "transparent diagonal," should be open to admit of the free escape of the transmitted heat. This method is so effectual, that substituting a piece of transparent glass for the small speculum in his great Newtonian silvered reflector, Mr. Bird was able to use his 12-inch aperture for nearly an hour without inconvenience, even during the intense heat of last May.

The most remarkable apparatus, however, and that which has led hitherto to the greatest discoveries, is "Dawes's Solar Eye-piece," so named from the eminent observer who invented it. In this arrangement, a metal slide is perforated with a series of holes, varying in size from 0·5 (or 0·3, which is safer for the screens) down to 0·0075 of an inch, any one of which may be brought into the centre of the field at pleasure. The greater part of the heat is so completely intercepted by the metal, which in turn is insulated by a plate of ivory from communication with the eye-piece, that the inventor has used this simple arrangement on Lassell's great 24-inch speculum for two hours of bright sunshine without unpleasantly heating the eye-

piece.* It is, of course, intended as an auxiliary to high powers, with which the diminution of light at the same time admits of the advantage of a thin pale screen-glass. In some instances of very large spots and a favourable state of air, the whole of the luminous surface may be excluded, and the spot, under clockwork, or very careful hand motion, be studied alone. This admirable contrivance is also useful without the dark glass for examining many other celestial phenomena where the brightness of neighbouring objects has a disturbing effect. In its latest modification, the various perforations and screens are arranged on circular plates, technically known as "wheels." Lassell's suggestion, that thick paper, covered with white lead, such as is used for glazed visiting cards, forms an admirable insulator as to heat, may be turned to good account in the construction of an economical arrangement to answer the same purpose.

There is, however, a totally different mode of observation, which, if less striking, and less adapted for minute details, than direct vision, is far more easy and convenient—that of *projection;* in which the image is transmitted through an ordinary eye-piece, adjusted by trial till perfect distinctness is obtained, to a large opaque screen at a suitable distance behind it. If this screen is white, smooth, and carefully arranged at right angles to the axis of the telescope, the correct focus being also carefully determined by repeated trial, this method will give a very fair representation of the principal solar phenomena. Mr. Howlett, indeed, who makes great and successful use of it, tells us that he even gets a more perfect view in this way than by direct vision. At the same time, it has the great merit of supplying us with an accurate and inexpensive micrometer, the image of the sun being made, by proper adjustment, to coincide with a circle graduated by lines into suitable divisions; and thus the position of the spots may be measured, and their progress made evident, from day to day. Carrington, one of our best solar observers, employed this mode, projecting the image on plate-glass, coated with "distemper" of a pale straw colour. A large piece of cardboard, with a hole in the middle, to slip over the object-end of the telescope in the place of the brass cap, must be provided to throw a shade upon the screen; and the latter, if measurement is the object, must be attached to a bar made fast to the telescope, and partaking of its motion.

Hornstein and Howlett, by inserting in the focus of the eye-piece, which for this purpose should be of the "positive" or

* Mr. Bird, however, with a mirror of only half the diameter, but reflecting more light in proportion from its silvered surface, found the brasswork greatly heated in about fifteen minutes. Much probably depends on the mode in which the apparatus is constructed.

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Ramsden construction, a slip of glass micrometrically divided, project its image, together with that of the sun, as a scale upon the screen. The latter gives the following dimensions, which may be useful as a guide:—Telescope $3\frac{3}{4}$ inches aperture, in a darkened room; power 80; cardboard screen on easel, 4 feet 2 inches from eye-piece; glass micrometer in focus divided to 200ths of an inch, each division giving about $\frac{1}{2}$ inch on screen, where a corresponding scale is drawn with ink, every 16th of an inch representing about 4″. With other powers, other distances would be required for the screen. With a good telescope, magnifying may, of course, be pushed much further; but beyond 80, or at the most 90, the field would probably fail to admit the whole disc of the sun. Captain Noble states that he obtains extremely beautiful views of the solar phenomena by fitting on to the eye-piece the small end of a cardboard cone, 1 foot long, and 6 inches across the larger end, which is filled by a disc of plaster of Paris, carefully smoothed while wet on a sheet of plate-glass; on this the image is projected, the interior of the cone being blackened, and an opening cut in its side to view the face of the plaster screen.

The observer by direct vision will not be surprised if he should find a different focus required for spots in the centre and those near the limb. This is a remark of long standing, but the direction of change has not been always accordantly given. Harding (Schröter's assistant) thought the focus shorter for the marginal than the central spots; Gruithuisen, Dawes, and Hind the reverse. Gruithuisen ingeniously ascribed this peculiarity to a negative refraction in the solar atmosphere;* Dawes, more soundly, to the effect upon the eye of the different intensity of light in the two regions, which is very considerable; and this view is confirmed by similar observations that he has made upon other objects, such as the brighter and darker portions of the moon, or the planet Saturn.

COLOURS OF STARS.

The diversity of colour among the stars is a fact which is apparent upon even a very cursory survey of the heavens. To some eyes it is probably much more evident than to others; the strange phænomenon of "colour blindness,"—in other words, a defective or incorrect appreciation of difference of hue—being, it is said, more common than is usually supposed. Still, the generality of spectators would at any rate be struck with the more extreme cases; for instance, a compa-

* By a curious coincidence, Sir J. Herschel and Mr. Hunt, in the early days of photography, were led to conclude that a class of rays having peculiar *negative* actinic properties issue from the edges of the sun.

rison of *Wega* and *Antares:* while a more delicate and trained vision, such as that of Admiral Smyth, will distinguish very minute and proportionally numerous gradations of tint, and detect the evidence of it even among those minute objects whose presence is only brought out by a patient and stedfast gaze. The attention of observers was early drawn to this point, Ptolemy, the Egyptian astronomer, having given a catalogue of six fiery, or ruddy stars, as far back as the second century. The invention and improvement of the telescope did not lead to so speedy an enlargement of our knowledge in this, as in some other respects; partly, perhaps, because the value of such observations was not at first recognized; and partly because the man who, in other respects, was the most qualified of all to give them due prominence—Sir W. Herschel—had a preference for ruddy tints, arising either from his eye or his specula, which rendered his results less valuable as a standard of comparison. Scattered notices of colour, after his day, are frequently to be met with; but in the works of Smyth and W. Struve, the subject has been treated with especial accuracy, and Dembowski and other observers are now following it up with close attention. It was not, however, till a comparatively late period that a very interesting question arising out of it attracted adequate notice,—whether those colours might be subject to change? A curious variation of hue had indeed been described by Tycho, in the magnificent temporary star of 1572, which, having at first broken out in splendid whiteness, passed, in its decrease, through yellow and red, into a somewhat livid whiteness again; but the instance was altogether so extraordinary that it naturally might excite no suspicion as to the possibility of a similar alteration among more permanent stars. Long after, but fully a century ago, Mr. Barker, of Lyndon, pointed out the probability that such a change had actually taken place in the most eminent possible instance, that of the resplendent Sirius itself, to which the ancients ascribed a reddish tint, now, as every one knows, totally imperceptible. Several of the expressions in classical authors may be equivocal, but we can have little hesitation as to the "rubra Canicula" of Horace, and still less as to the distinct assertion of Seneca, that its redness was more vivid ("acrior rubor") than that of the planet Mars; while Ptolemy, in the list already referred to, ranks it, together with Arcturus, Aldebaran, Pollux, Antares, and Betelgeuse, as ὑπόκιρρος—fiery-reddish. The date of its change is unknown; but it seems probable that its redness had already become inconspicuous in the days of El-Fergani (Alfraganus), in the middle of the tenth century, and no one now would even suspect its former existence; it may, perhaps,

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even be thought to verge a little toward the opposite, or blue, end of the spectrum. But, whatever probability might attach to Mr. Barker's investigation, the subject seems to have been subsequently neglected; at least, I have not noticed any further reference to it till Herschel II. and South published, in 1824, their catalogue of double stars. In this, remarking upon the smaller star of *ι Cancri*, which Herschel I., 1782, Feb. 8, had found of a deep garnet colour; Dec. 28, bluish; 1785, March 12, blue, and which they had noted as indigo blue, 1822, Feb. 22, they take occasion to inquire, "Are the colours of the stars liable to change, as well as the intensity of their light? There is no impossibility in this, and the point merits attention." This it has subsequently received, but hardly, as yet, in the degree which it deserves; the time, however, is now obviously come when a more general and rigid investigation may and should be attempted. Fortunately for amateurs, the inquiry is perfectly accessible, in the vast majority of instances, with moderate instrumental means, and, for some not very obvious reason, contrast of colour is frequently as perceptible with small as with larger apertures. And it is an inquiry which calls for an extended combination of effort, for it will be found that it is only by an accumulation of independent and concurrent testimony that we can hope to attain to any reliable conclusion. We have already touched upon this subject at the beginning of our list of double stars (Intellectual Observer, No. 2, p. 148); but it is desirable to advert to it again a little more in detail. Many adventitious circumstances are unfavourable to the results of any single observer. From an inherent defect in their construction, achromatic object-glasses do not form an image as perfectly free from colour as the derivation of their name implies; there is always, under high powers, a narrow fringe of tinted light surrounding every bright object in focus; and as this tint had been originally a constituent part of the light of the star under examination, previous to its decomposition by the imperfect action of the object-glass, the focal image formed by the remainder of the light cannot be precisely of its natural hue, but must be more or less tinged with the complementary colour. By "complementary" colour is meant that which makes up the *complement* of white light after any given tint has been separated from it:—thus, considering with Sir D. Brewster that white is compounded of certain proportions of the three primary colours, red, yellow, and blue, we shall find that red is complementary to a mixture of blue and yellow, forming green; that yellow is complementary to a combination of red and blue, forming purple or violet; and that blue is complementary to an union of red and yellow, that is to say,

orange; and the same holds good with regard to the secondary or mixed colours. If, therefore, a telescope has, as usual, a fringe of blue or purple "outstanding," as it is termed, when in focus, the image of a white star will be, in proportion to the strength of the fringe, slightly stained with the complementary orange or yellow; such, for example, was the case with the noble achromatic at Dorpat—one of the first instances, if not the first, of a combination of magnitude with perfection, and with which W. Struve's great catalogue of double stars was formed; what were considered *moderate* powers in this instrument, 254 and 420, were preferable to 532 and 682, as the latter gave a yellowish tinge. And such is probably especially the case with other productions of the Munich Optical Institute, whose glasses are said to be characterized, notwithstanding their fine definition, by a great deal of outstanding blue. In addition to this never-failing source of discoloration, the fact that different object-glasses may not possess the same intensity, or precisely the same hue, of outstanding fringe, may somewhat vary the colour of their respective focal images; the material, too, of the older glasses would exercise an influence, the crown glass formerly employed having a strong green cast, from which the modern plate is comparatively free. This coloured fringe is entirely absent in reflecting telescopes, whence their focal image, when equally sharp with that of the achromatic, is more pleasant to the eye; but the Gregorian construction was apt to exhibit a "smoky" tinge; and though Newtonians, for some reason which does not plainly appear, are less subject to this, it may be readily induced by using too much copper in forming the speculum metal, or by a slight amount of tarnish. From all these defects, it is pleasant to know that the silvered specula, now coming into use,* are quite exempt, and nothing can surpass the intense purity of their reflection so long as they retain their original brilliancy, which, there is every reason to believe, may, with due care, be preserved for many years, and may be always perfectly restored with great facility. We must bear in mind, too, that even the most faithful focal picture may receive a tinge from being viewed through a defective eye-piece, though this is not much to be apprehended, provided the object is kept in the centre of the field.

* The following very interesting announcement is taken from a Paris newspaper, of May 27:—"L'Association pour l'Avancement de l'Astronomie et de la Météorologie——tiendra une Séance Générale le 3 Juin, à l'Observatoire, à trois heures de l'après-midi. Le président exposera le but de l'Association. Le nouveau grand téléscope de 0^m 80, monté équatorialement, sera expliqué; le procédé d'argenture du miroir sera expérimenté." The fraction of a "mètre" here given is equal to 2 feet 7½ inches, English measure.

The atmosphere also introduces a certain amount of occasional deception. It is obvious that a degree of haze which gives a red or yellow tinge to the sun by day must produce the same effect on white stars by night; and on this account the colours estimated on different nights might be found to vary, and even on the same night at different altitudes above the horizon. Hence the tints of low-culminating stars can seldom be satisfactorily determined, even if we could eliminate the effect of refraction, which interferes again in its own way, converting circular discs into lengthened and parti-coloured spectra, and sometimes, as Smyth observes, making "a large star of a white colour really appear like a blue and red handkerchief fluttering in the wind; the blue and red about as intense and decided as they could well be." The lowest 10° or 15° of the visible heavens are on this account commonly condemned by astronomers as useless; but Herschel I. found traces of this prismatic effect even as high as *Regulus*, and observed that from this cause a star was not always best seen in the centre of the field, there being a position where the prismatic error of rays passing obliquely through the eye-lens may, in some measure, correct that arising from atmospheric refraction. Struve, in later days, traced prismatic effects from this cause to 30° and even 45° from the horizon.

Some care should be taken as to the standard and nomenclature of colour, as discrepancies may arise from carelessness or inattention on this head. There is unquestionably a natural or intrinsic standard of colour in the primary tints of the spectrum, but they do not come before us in an unmingled form decidedly or frequently enough to be impressive on the memory; practically speaking, each blue that we see may be thought greener or more purple, if compared with other shades verging more to purple or green than itself; and so our ideas of yellow oscillate through a considerable interval between green and orange; and red has many variations between orange and purple. Besides this, the language of many persons is habitually vague; and in the case especially of mingled tints, different names might be given by different persons to the same colour. To obviate these causes of uncertainty Smyth's excellent suggestion should be adopted, of referring all hues to corresponding water-colour pigments, where the definite name admits of no question, provided only the memory of the eye may be depended upon.

But besides these comparatively external sources of error, we have to observe that the judgment of the eye itself may be easily led astray. To the difference which, as has been already intimated, may exist between the perceptions of different individuals, we have to add those which may casually arise in the

same eye at different times from varying conditions of the retina. To say nothing of the probability that a wearied eye would be less sensitive to slight differences of tint than a fresh one, it is well known that the long-continued impression of light of any decided colour is succeeded, upon its removal, by the appearance of the complementary hue—a fact which may be illustrated in a pleasing manner by closing one eye, and looking with the other at a white object through a piece of strongly tinted glass; this having been continued for a sufficient time till the sight is accustomed to it, let the glass be suddenly taken away, when the complementary colour will fill the whole field of vision, to an extent that will be fully manifested by opening the closed eye, which of course will see only white light. In exactly the same way, the eye which has been long gazing upon a bright yellow star, on turning the telescope to a white one, will see it tinged with the complementary purple, or, if the star was of a red hue, with the corresponding green. The cause of this phænomenon may probably be, that diminution of sensibility under a long-continued and unvaried stimulus which is common to all our perceptions. The retina becomes gradually less responsive to the action of any colour, just as it is to the action of strong white light, from prolonged exposure to its unmixed influence; and therefore when light composed of various tints is subsequently let in upon it, it fails in the adequate perception of that hue to which it has become as it were deadened, and catches chiefly the impression of the other colours in the compound, until the retina has had time to recover its normal condition. On this account, the observation of colour should never be attempted after micrometrical measurement, in which artificial illumination is employed; nor indeed at any time when the retina has just been previously stimulated by lamp or candle-light. So Struve I., who paid great attention to colours (while his assistant Knorre could distinguish none!), has cautioned us that tints observed by daylight are not to be depended upon; the impression of the blue background predisposing the eye to ascribe a tinge of complementary orange to the star, exactly as we have seen the light of a cloudy sky, penetrating through a hole in a window of greenish glass, appear distinctly of a lilac colour.

Another inquiry, and rather a troublesome one, springs out of this relation of the retina to colour. Since a coloured light of predominant intensity will obviously tinge all lesser lights in its neighbourhood with the complementary hue,* a

* It is probable that intensity of hue may occasionally overbalance mere quantity of uncoloured light. At least the slight green tint of *Sirius* when brought into the same field with *Arcturus* in Chacornac's ingenious experiment on their relative brightness, may be reasonably ascribed to that cause.

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fact which may be easily illustrated by observing the blue aspect of the moon in the presence of a powerful lamp or gas-light, what certainty can be obtained as to the real colour of the smaller components of double stars, where the principal has any decided hue? In many instances, as when yellow stars are attended by little lilac *comites*, the suspicion of mere contrast naturally obtrudes itself. In others where the tints are not complementary, that of the smaller star is sure to be modified in some way, unless the principal is white; and even then it is not impossible that a small white attendant, lying within the outstanding blue fringe of the large star, might receive an orange or tawny tinge from its position—an illusion which I think I have noticed. The difficulty can only be fully met by inserting a bar or thick wire in the field, and keeping the larger star behind it by hand or clock motion, till the eye has recovered from the impression of the stronger light. By this method of artificial occultation Arago satisfied himself that most frequently the colour of the smaller star was not the mere effect of contrast; and Struve I. found that the beautiful blue of the two companions o^2 *Cygni* (No. 58 of our Double Star List, Intellectual Observer, Nov. 1862, p. 304) was independent of the presence of the large orange star. Where great accuracy is desired, and a driving motion can be applied, it would be advisable, after hiding the principal star, to close or avert the eye for a short time, that an entirely fresh impression of the colour of the companion may be obtained.

When both eyes are of equal goodness, which is by no means always the case, the employment of each in succession in the examination of colour may prove an useful check upon any accidental bias in either. A change, too, of eye-pieces may always be expedient. The tints of close double stars are seldom so plainly seen with low powers as with higher ones, which give a wider separation to the discs.

Not unfrequently an observer finds considerable trouble in satisfying himself as to the tint of a star. In some cases this probably happens from the want of a standard of white light in the field. Could this be constantly introduced by the method of reflection employed by Chacornac to estimate comparative brightnesses (see last number of Intellectual Observer, p. 385), it would be a great assistance, and well worth the consideration of an observer who made this subject his special study. In other instances the eye seems puzzled and the tints fluctuate. I have repeatedly remarked this in the smaller components of certain double stars—α *Piscium* being a remarkable instance—which are described as blue by Smyth, but appeared to me sometimes of that colour, sometimes tawny, in the course of a single observation. That this is not alto-

gether a peculiarity of vision I am induced to believe from the strange discrepancy that exists as to the colours of *α Piscium* (see INTELLECTUAL OBSERVER, Feb. 1863, p. 55, No. 80). In default of a better explanation, I have thought it possible that in consequence of intense gazing the retina may have become deadened to the blue tint, and consequently would see the star white, but for the complementary orange induced by its being involved in the outstanding blue fringe of its brighter companion: this accidental hue in turn disappearing, as the eye recovers itself, to give place to the original blue; and so on. Mr. Knox agrees with me as to the existence of this fluctuation.

We must postpone to another opportunity a few more remarks upon this subject.

CONSTITUTION OF NEBULÆ.

Those who have studied one of the most remarkable questions of modern astronomy—that relating to the true nature of nebulæ properly so-called—will be extremely interested to learn that from the observations of Mr. Powell, at Madras, there is great reason to infer that the remarkable nebula round the star *η Argûs* is gradually but strikingly changing its form and brightness. It is figured in Herschel's *Outlines of Astronomy*, but is unfortunately not visible in European latitudes. We shall now have a renewed inducement to a closer examination of the analogous nebula in *Orion*.

TRANSITS OF JUPITER'S SATELLITES.

July 2nd. Shadow of I. goes off 9h. 50m. 8th. Shadow of II. departs 9h. 51m. 9th. Shadow of I. enters 9h. 33m. I. leaves the disc 10h. 38m. 15th. II. goes off 10h. 2m.; its shadow entering 2m. later. 16th. I. enters 10h. 17m. 22nd. II. enters 10h. 8m. 25th. Shadow of I. passes off 10h. 5m. 29th. Shadow of III. enters 9h. 19m.

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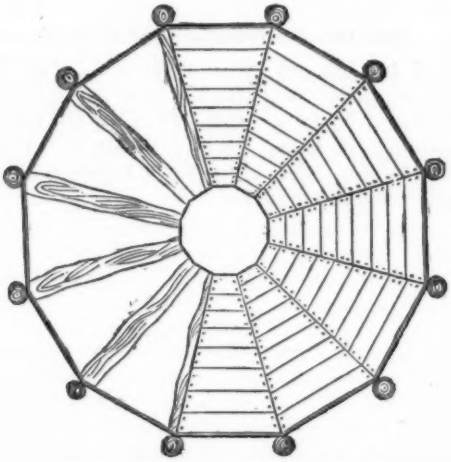
A GARDEN OBSERVATORY.

ELEVATION.

Diameter inside, 10 ft.; height to apex, 10 ft. 6 in.; to plate, 5 ft. 6 in.



GROUND PLAN. Scale, ½ in. to 1 ft.

THE ROMSEY OBSERVATORY.

BY REV. E. L. BERTHON.

(*With Illustrations.*)

THE following description of a very inexpensive garden observatory will most probably be acceptable to those amateur astronomers who have felt the want of a shelter for their instruments and themselves, and have hitherto been deterred from the enjoyment of such a luxury by the supposed costliness of its erection.

In the INTELLECTUAL OBSERVER for May, 1864, appeared a description of a cheap observatory recently built by Mr. Bird for his large silvered-glass reflector, and it is, the writer is assured, with the best wishes of that able astronomer that the present account of a *cheaper* observatory makes its appearance.

It is not necessary to repeat the cogent reasons that those who study the hosts of heaven in the chilly night should do so with as much comfort as possible. A cutting wind on a frosty night, which agitates both the observer and his telescope together, is the best argument in favour of laying out a few pounds for such a purpose.

The drawings which accompany this description represent, in elevation and ground plan, a very pretty rustic observing-house, which the writer erected in the garden of Romsey vicarage last summer; it has answered every desired purpose most perfectly, and though the situation is wet, being almost surrounded by water, the building itself is remarkably free from damp of every kind, not a speck of rust having appeared on some bright steel and iron work kept in it the whole winter. It will be seen that the form of the building is twelve-sided, and the following particulars will enable any one desirous of adopting the design to build it:—

Twelve rough fir poles, or any straight trees, about four inches thick and eight feet long, are fixed in the ground in a true circle ten feet diameter, and at equal distances from each other, *i. e.*, about two feet six inches; their tops must then be cut off level six feet six inches above the ground.

To do this part of the work quickly and well, a straight post should be set up in the centre of the circle, on the top of which a horizontal rod five feet two inches long is made to revolve; this will indicate the height of each post and the position of the centre of its head. This being done, some pieces of inch deal or other plank must be cut just long enough to

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reach from centre to centre of the posts, and these twelve pieces, four inches wide, must be nailed on their tops.

The walls of the house must now be made by nailing weather-boards on the inner sides of all the posts, beginning at the upper part, and only leaving the apertures for the door and windows.

The bearers for the floor can be laid next; they consist of slabs of any kind of timber with their smooth sides up. Supposing the brick or stone pedestal for the telescope to be two feet in diameter, these slabs will be four feet long; they may be supported on logs of wood, or any other blocks, so that the floor when laid upon them is one foot above the ground. Care must be taken that neither they nor the boards touch the pedestal.

The ground plan shows the arrangement of the boards, five of the spaces being left open in the drawing to show the bearers.

The door and windows can be made according to the taste of the builder, but simple and neat cases for them can be formed by nailing inch board, planed, against the rough posts. Very simple frames for the windows, with one large square of glass in each, look quite as well as casement, and are very cheap.

The next part is the roof, which is constructed as follows:—Twenty-four pieces of inch plank, about six inches wide and between two and three feet long, are so cut that twelve of them shall form a circle ten feet three inches wide at its inner edge; these being laid out in a true circle, marked in chalk upon a flat floor, the other twelve are laid upon them, crossing the joints; they are then all nailed together and clinched. The inner edge is then made to a true circle, and smoothed with a compass plane.

Next the rafters must be cut, twelve or twenty-four in number, or intermediate as best suits the canvas. The Romsey Observatory has twenty-four; they are seven feet six inches long, and two by one inch thick. Being cut to the right bevel, their feet are simply nailed down to the great wooden ring above described; their upper ends meet on a block surmounted by a knob.

Strong canvas is now to be nailed with tinned tacks upon the rafters. A space will be left in the roof nearly six feet wide, wherein no rafters are fixed. It is the opening for the telescope, and is closed with shutters in this way:—Suppose the number of rafters be only twelve, then *two* triangular frames of the same wood, each comprising one-twelfth part of the cone, will be hinged to the contiguous rafters on each side, and the canvas nailed over the joints. A broad thin strip of

wood covering the part where these shutters meet will keep out the rain; the only place where it might come in is at the extreme apex, and to prevent it a round disk of zinc must be put on under the knob, but high enough above the upper ends of the rafters to allow the triangular shutters to open. The writer has constructed his shutters in four pieces, hinged two and two together, so that he can open them from eighteen inches to six feet.

The roof being completed and well painted inside and out, is ready for lifting on, which can be done *bodily;* but first the gear for causing it to revolve must be contrived. For this purpose eighteen iron sash-rollers of good size must be got from any good ironmonger. Twelve of these must be sunk in the plates of wood on the top of the posts, and just over them. The other six rollers must be attached to some stout blocks of wood, so as to revolve vertically, and these blocks will be screwed to the plate, between the posts, in alternate spaces, so that when the roof is on, the inner edge of the great ring or circle touches, or may touch them, to prevent the roof going off sideways. The twelve rollers should be well oiled, and they will be found to bear the roof, and allow it to revolve with a very moderate force.

The shutters must have a bolt to keep them shut; and about four bent pieces of iron driven into the top of the posts, with a sort of hook projecting a little over the inner edge of the great circle of the roof, will keep it from being lifted by the wind.

It only remains to remark that the extreme dryness of this building arises from its being raised a foot clear from the ground, but it is better and warmer if roofing-felt be nailed on inside the boards. Some very cheap stuff, cotton or linen, etc., nailed inside the felt will receive the paper which, with a simple cornice, finishes the interior.

The weather-boards outside can be tarred over or painted roughly, and where loppings of oak can be had, some of the crooked branches put on in a gothic pattern produce a very pleasing effect. The eaves can be ornamented according to taste or local facilities.

The following is an estimate for materials and labour on a high computation, not including the pedestal of the telescope; but in most parts of the country, especially where English fir can be obtained, and the wages of a carpenter are less than five shillings a day, a considerable saving may be effected, so that the expense of this pretty little building will vary from seven to ten pounds, according to local circumstances:—

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Twelve rough fir poles	£0	12	0
One hundred and sixty-five feet of three-quarter inch weather-board for sides, at 2*d.* per foot	1	7	9
One hundred and sixty feet of inch deal board at 2½*d.* per foot, for floor, plate, windows, door, and entire roof . .	1	13	4
Slabs for bearers of floor . . .	0	4	0
Fifteen yards of yard-wide canvas at 1*s.* 4*d.*	1	0	0
Eighteen sash-rollers (iron) . . .	0	3	0
Nails, screws, and tacks . . .	0	8	0
Lock, hinges, and bolts . . .	0	6	0
Eight square feet of glass for windows at 3*d.*	0	2	0
Eighteen yards of roofing-felt for inside of weather-boards	0	12	0
Eighteen yards of lining . . .	0	6	0
Paint, etc.	0	6	0
Labour, twelve days at 5*s.* . . .	3	0	0
Total	£10	0	1

ON THE ORIGIN OF THE LIGHT OF THE SUN AND STARS.

BY BALFOUR STEWART, M.A., F.R.S.

When we turn our eye upwards and behold the sun, or gaze by night on the starry firmament, and reflect that those glorious orbs have shone through unnumbered ages, we cannot fail to be impressed with the majesty of that Great Being who upholds them in all their brightness. But if we descend from the great First Cause to those modes of action in accordance with which we are assured the universe is governed, and search for the source and fountain of this brilliancy, we have to grapple with one of the most perplexing problems in the history of Science.

And this perplexity has only increased with the progress of knowledge, nor has it ever been greater than it is at present. In the days of old the sun was looked upon as a ball of fire, and no question was raised about the source of his heat. But in proportion as we have become better acquainted with the various probable sources of light and heat, and are convinced that the laws of matter, nay, even its very forms, are the same throughout

the universe, in the same proportion are we perplexed to assign the producing cause of such a wonderful outflow of luminosity.

All speculations on this subject naturally divide themselves into two groups. We have, in the first place, those which assume that the sun and stars are fed from within; and, in the second, those which assert that they are fed from without. A little explanation will make this distinction clear. If we suppose the sun to be a huge mass at a very high temperature which is gradually cooling, and therefore giving out light and heat, or if we suppose his brightness to be due to chemical combination of the substances which form his mass, in either case we assert that he is fed from within. But, on the other hand, if we suppose that he is fed by comets, or by meteors impinging against his atmosphere, and having their motion converted into heat (just as they have when they impinge against the atmosphere of the earth), or by an external ether, or in any way by planets, then we assert that he is fed from without. In presuming to add another to the list of these speculations, let us begin by laying down certain rules to guide us in our discussion.

Now, first of all, our hypothesis must not be inconsistent, or only barely consistent with appearances on the sun's disc; and, in the second place, it must be susceptible of application to other systems, and capable, by a legitimate extension, of explaining the very strange and even startling phenomena which reach us from those distant regions. The sun, in fine, must not be regarded as an individual apart by himself, but rather as that member of a large family with whom we are best acquainted, and who, if questioned aright, may perhaps inform us of the habits of his race. What, then, are the phenomena which he presents? It is well known that his surface, although generally appearing uniformly luminous to the naked eye, is not so in reality. Setting aside spots for the moment, the centre of his disc is decidedly brighter than the circumference; leading us to infer that the sun, like our own earth, is surrounded by an atmosphere which absorbs much of the light which passes through it in an oblique direction. It is likewise worthy of remark, that this atmosphere must have a lower temperature than the region which gives rise to the luminosity, since otherwise it would not exercise an absorptive influence upon the light emitted, but would add as much as it took away, or even more, if its temperature were higher. The dark lines in the solar spectrum are likewise a proof of the presence of an absorbing atmosphere of low temperature.

But the spots which appear from time to time on the sun's surface are at once the most interesting and instructive of all solar phenomena. Their existence has been known for a long

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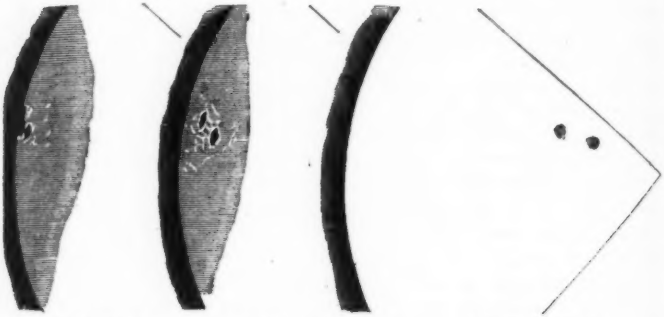
time, but it is only lately that they have become the subject of scientific study. The following sketch from solar photographs taken at the Kew Observatory will give an idea of these curious objects :—



Left Limb of the Sun, 1863, July 5th, 12h. 24m. p.m. Left Limb of the Sun, 1863, July 6th, 11h. 40m. a.m. Left Limb of the Sun, 1863, July 10th, 12h. 17m. p.m.

In the first of these pictures we perceive a group consisting of two spots, which has just been brought into the field of view by the rotation of our luminary. It will be noticed that, beyond the spot at the extreme edge, there is a slight luminous thread, otherwise this spot would have produced an apparent indentation in the sun's limb. In the next picture the group has advanced a little further into the disc; and we now see a large quantity of bright flocculent matter floating about chiefly between the two spots. We likewise perceive from this, as well as from the previous picture, that the circumference of the disc is less luminous than its more central portions. The second picture affords us also an opportunity of observing minutely the two spots which form the group. We see that each consists of a black nucleus, accompanied by a penumbra, which, in the left-hand spot, is almost, if not quite, to the left of the nucleus. In the third picture, that group has advanced nearly to the centre of the disc; and here we find, in both spots, that the nucleus is very nearly central with respect to the penumbra, and that there is a total absence of bright flocculent matter, or faculæ, as this is sometimes termed.

By the nearly unanimous opinion of observers, spots have been regarded as breaks in the photosphere of the sun, through which his comparatively dark body becomes visible. The first scientific observer was Dr. Alexander Wilson, of Glasgow, who upheld this hypothesis by endeavouring to show that when a spot is near the sun's limb, the nucleus is generally nearer the

centre than the penumbra. From this he argued that a spot represents a cavity of considerable depth in the sun's atmosphere; the dark body of our luminary forming the nucleus or bottom, while the penumbra represents the atmospheric walls or sides of the cavern; a consequence of which will be, that when a spot is placed obliquely towards us, the wall nearest us will be hidden from our view, and we shall only see that which is farthest away. It will be noticed that one of the spots we have sketched confirms the truth of this explanation, the penumbra being to the left of the nucleus when the spot was near the sun's left limb.

Let us now consider the light-clouds, or faculæ. Messrs. Dawes, Howlett, and others, have observed that a spot, when near the edge of the sun, does not cause an apparent indentation in the limb, as might be expected, but that there is always a thin line of light beyond. This is also seen in our sketch, and the original negative at Kew from which it is taken, is exceedingly instructive and well worthy of minute inspection. It represents the line of light at its central portion as more luminous than the general body of the sun, so that the eye is impressed with the idea of an excessively curved or bulging out line. This may be due to the elevation of the luminous ridge above the body of the solar atmosphere, and is in accordance with the well known fact that when faculæ are observed near the limb of the sun they appear much brighter than the surrounding photosphere, as if by being high up they escaped a great portion of the atmospheric medium which absorbs very much of the light proceeding from the border.

On the other hand, faculæ have little or no excess of brightness when near the centre of the disc, because there the light travels only through a small extent of atmosphere and there is not much gained by escaping it. To all this we may add, that Mr. Warren De la Rue has succeeded in producing a stereoscopic image of a spot in which the faculæ appear raised above the surface. Now if these faculæ are really elevated, this seems at once to inform us that the sun's light breaks out in his atmosphere and does not come from his solid body, since we cannot easily suppose large masses of heavy matter remaining upheld at a great height for a long period of time. We therefore conclude that the greater proportion of the light which reaches us is not derived from the solid body of the sun, but from some matter which either floats in the solar atmosphere or forms part of this atmosphere itself, and also that as far as our observation of spots extends, there is ground for supposing the sun's surface to be deficient in luminosity; and, for a body of indefinite thickness, this is equivalent to a reduc-

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tion of temperature. It is of course possible to imagine that a peculiar cooling process takes place, so that the body of the sun, originally very bright, is greatly reduced in temperature when we behold it, but such an hypothesis bears the appearance of patchwork, and even if it account for solar phenomena, it will not admit of extension to other systems. From all this, we are induced to suppose that the sun's light is due to action from without; and if it can be proved, as we think it can, that a disc full of spots is deficient in luminosity, it would seem to follow that such a state of the sun's surface implies a deficiency in the intensity of this mysterious action; while, on the other hand, a disc free from spots denotes an increase of the same.

If we now direct our adventurous flight into still more distant regions, we shall find evidence of very extraordinary forces at work in stellar spaces. We allude to variable, temporary, and binary stars. Of the first and second of these classes we shall here name one or two of the most prominent examples.

1. Omicron Ceti has its greatest brightness for a fortnight, decreases for three months, is invisible five months, increases again for three months, arriving once more at its greatest brightness.

2. Algol in Perseus appears for about sixty-two hours as a star of the second magnitude; it then suddenly becomes fainter, and in three hours and a half arrives at its minimum; it then begins to revive, and in three hours and a half more is again at its maximum brightness.

3. Gamma Cygni is visible for about six months, and invisible for about the same time or a little longer.

The appearance of a temporary star about 125 years B.C., which shone forth for some time with extraordinary brilliancy and then died away, turned the attention of Hipparchus to astronomy, and induced him to form a catalogue of stars. In the year 389 A.D., a star shone forth with extreme brilliancy near Alpha Aquilæ, remained for three weeks as bright as Venus, and then disappeared. A star of this kind was first seen by Tycho Brahé in November, 1572. It was at its greatest brilliancy when discovered, diminished gradually in brightness for sixteen months, and disappeared in March, 1574. There was no change in its apparent place. Kepler also saw a new star on the 8th of October, 1604. It had suddenly become visible, was of great lustre, and disappeared after twelve months.

This is perhaps the fittest place to notice the behaviour of binary stars. A binary star denotes a system generally of two members which revolve about one another in ellipses frequently of great eccentricity. A change of magnitude in the components of some of these systems has been observed, and, as far as can be gleaned from an interesting paper by Professor

Piazzi Smyth, when this is the case both components change together and in the same direction. We may soon hope to learn something more definite regarding these bodies, which are favourite subjects of study, but in the meantime our knowledge is very limited.

From all this it is evident that in the case of many stars we cannot suppose the light to be due to an incandescent solid or liquid body, otherwise how can we account for their long-continued disappearance? Goodricke indeed has supposed that dark bodies may periodically obscure them, but the objection to this hypothesis is, that such a dark body would be of a size utterly disproportioned to that of any ordinary star. Nothing appears so capable of explaining all these phenomena as the supposition that the luminosity of stars is derived from without, and that when the source of excitement fails or varies we have a temporary or variable star. Driven, therefore, to look without for the source of solar and stellar light, let us examine the various hypotheses which have been proposed.

It has been argued that the etherial medium which pervades space may somehow produce luminosity at the surface of large bodies, towards which it may be supposed to stream, and that some of its streams being stopped by planets or other bodies, this may occasion a variation in the light of the primary; yet how, on this principle, are we to account for the total stoppage of light for a lengthened period of time? Again, it has been supposed that our sun is fed by meteors, which, falling into his atmosphere, have their motion at once converted into light and heat. Accordingly, when a star is in a portion of space rich in meteors, its brightness will be intense; but when in a space devoid of meteors, it will disappear. This will readily account for the behaviour of temporary stars, but it cannot easily be tortured into affording us an explanation of variable ones. In advancing our own views, let us remark that in a case like the present we should endeavour to connect together such phenomena as are periodical. Can these appearances, then, be in any way due to planets? And again, since observation only can decide this question, have the spots on our own sun any relation to planetary configurations? In the valuable work on sun spots, recently published by Mr. Carrington, a comparison is instituted between the frequency of sun spots and the radius vector of Jupiter, and on the whole there are good grounds for supposing that the least distance of Jupiter from the sun corresponds in epoch to the minimum of spot-frequency, and his greatest distance to its maximum. It may be added that in 1837 the number of spots was peculiarly great, and that both Jupiter and Saturn were then nearly at their greatest distances

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from the sun. Furthermore, an examination of the sun-pictures taken by the Kew heliograph, seems to indicate the following law. Any portion of the sun's disc which, owing to his rotation, recedes from the neighbourhood of Venus, acquires a tendency to break out into spots, and as it approaches Venus it acquires a tendency to be free from spots. On the whole, therefore, we are perhaps entitled to conclude that, in our own system, the approach of a planet to the sun is favourable to luminosity, and especially in that portion of the sun which is next the planet. A confirmation of this law is found in the readiness with which it may be adapted to other systems. Let us take variable stars. The hypothesis which without being physically probable gives yet the best formal explanation of the phenomena there presented, is that which assumes rotation on an axis, while it is supposed that the body of a star is from some cause not equally luminous in every part of its surface. Now if, instead of this, we suppose such a star to have a large planet revolving round it at a small distance, then, according to our hypothesis, that portion of the star which is near the planet will be more luminous than that which is more remote, and this state of things will revolve round as the planet itself revolves, presenting to a distant spectator an appearance of variation with a period equal to that of the planet. Let us now suppose the planet to have a very elliptical orbit, then for a long period of time it will be at a distance from its primary, while for a comparatively short period it will be very near. We should, therefore, expect a long period of darkness, and a comparatively short one of intense light—precisely what we have in temporary stars. Again, we have seen that in many binary systems there is a change of magnitude, and that perhaps both members change at the same time and in the same direction—a result in favour of our hypothesis; but it is to be regretted that we have not yet sufficient data for determining if the brightness is greatest when both members are nearest together. Perhaps it may now be asked, If the sun have not a large store of heat in himself, but is fed from moment to moment, have we any guarantee for the continuance of his light, or for its steadiness, which is almost of equal importance to our well-being? We reply, that our sun is not the member of a binary system of small period and large ellipticity, which might give him a variable brightness, nor is he surrounded by planets that now press near to him and anon recede to a great distance, which might produce the same result. No doubt we encounter occasionally an erratic comet and are much puzzled by its great luminosity and, in other respects, strange behaviour, as it approaches our sun, but the influence of a body of such small mass upon our luminary is probably inappreciable.

We have thus endeavoured to show that the formal law which appears best to represent celestial phenomena, asserts that the approach of two heavenly bodies produces light. Now what physical cause does this imply? It has been remarked by the writer, in conjunction with Professor Tait, that we are not without an analogous law in another branch of science, for we know that the approach of two atoms towards one another also produces light. Again, is it not conceivable that the law indicated in this paper may be merely that arrangement by means of which the visible motion of bodies is converted into light and heat, which we know, from Professor Thomson, are the ultimate forms to which all motion tends. This problem is one of great interest, but it can only be solved by laborious observation.

LITERARY NOTICES.

Outlines of Astronomy. By Sir John F. W. Herschel, Bart., K.H., etc., etc. Seventh Edition (Longmans).—There are very few scientific works that can compare with Sir John Herschel's well known "Outlines of Astronomy," as a masterly exhibition, not only of the fundamental facts, but of the methods of reasoning in the higher branches of physical inquiry. Many writers have succeeded in giving intelligible explanations of the principal astronomical laws, and of the results to which they give rise; but we could name no book equal to the "Outlines," in its capacity of making physical science an aid to a vigorous and yet pleasurable training of the mind. The leading facts and principles of Astronomy remaining unchanged, that which was well said concerning them when the first edition of Sir John Herschel's work left the press, is equally applicable now that the seventh edition appears in answer to public demand; but still there are some departments, in which recent researches have unfolded new truths, that require more notice than they have received in the volume before us, which is very little more than a reprint of the last edition. If Sir John Herschel's age and engagements prevented his paying due attention to the views concerning the constitution of the sun, which have been unfolded by the application of the spectroscope, and by considerations resulting from the mechanical theory of heat, and to other recent speculations and observations, it would have been wise to have transferred the task of bringing out a new edition of his famous work to his son Alexander, who has displayed scientific capacities of no common order, and bids fair to be known to posterity as the third of his illustrious name. But although we thus express a wish that we had been favoured with a little more, that which Sir John again offers to us is essential, and nowhere else presented equally well.

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INSTANCES OF THE POWER OF GOD AS MANIFESTED IN HIS ANIMAL CREATION: A Lecture delivered before the Young Men's Christian Association, Nov. 17, 1863. By PROFESSOR RICHARD OWEN, D.C.L., F.R.S. (Longmans.)—This is the lecture that gave rise to so much discussion and anger in the minds of certain well-meaning gentlemen whose defective training peculiarly needed to be supplemented by the kind of instruction which Professor Owen provided for them. No one can doubt the religious tendency of Professor Owen's mind: he has always contemplated science in the light of natural theology, and his main line of argument would be followed by nine-tenths of that now numerous section of the clergy who have thought their performance of duty incomplete without a reverent study of God's works.

THE ROSE BOOK: A Practical Treatise on the Culture of the Rose; comprising the Formation of the Rosarium, the Characters of Species and Varieties, Modes of Propagating, Planting, Pruning, Training, and Preparing for Exhibition, and the Management of Roses in all Seasons. By SHIRLEY HIBBERD, F.R.H.S., etc., etc. (Groombridge and Sons.)—Every family tries to grow roses after a fashion, from those who confine their labours to a humble pot in the chamber or window sill, to those who can afford to lay out rosariums, or line long garden-walks with the all-favourite flower. Rose culture is indeed one of the most important branches of gardening as a fine art, and thousands are annually baffled and defeated for want of the practical instruction which Mr. Hibberd here gives. The wealthy cultivator with acres of lawns and beds, will derive from his pages ample information, much of which is usually concealed as a secret of the craft, while more modest growers will be saved from many a mistake. To the inhabitants of towns and suburban districts, he affords great comfort by indicating what sort of roses they must choose, and how they must treat them to ensure success. Mr. Hibberd is well known as a most indefatigable experimenter, and what he recommends to others he has first tried and proved for himself.

THE TEMPLE ANECDOTES. By RALPH AND CHANDOS TEMPLE. INVENTION AND DISCOVERY. Illustrated; published monthly. No. 1. (Groombridge and Sons.)—Everybody likes good anecdotes, and everybody likes good illustrations; and here they are, at a price wonderfully low, considering the admirable quality of the type, paper, and engravings. No. 1 of the "Temple Anecdotes" contains twenty-eight anecdotes of great inventors and great inventions, besides a brief introductory essay on the "True Mother of Invention." Arkwright, Cuvier, Stephenson, Crompton, Brunel, Buckland, Watt, and Wollaston, are among the heroes of the incidents narrated, and the editors have shown industry and discretion in hunting up striking and little known facts. Arkwright's wife destroying his models, and an incident in the childhood of James Watt, furnish subjects for two full-page elaborately-executed engravings, which belong to a style of art seldom seen in cheap publications. They are both good, but the second is especially

admirable both in design and execution. The earnest boy tracing his mathematical diagrams on the stone hearth, unconscious that his father and two visitors are watching him; the calm, thoughtful satisfaction of the parent, who is hopefully speculating on his child's future career, and the varied expression of the two ladies, are presented to us by the artist with a force and fidelity seldom seen in more pretentious works.

THE ABBEVILLE JAW: An Episode in a Great Controversy. By J. L. ROWE, F.G.S. (Longmans.)—This is a paper read before the Hull Literary and Philosophical Society. The author is a bit of a humourist, and his chief object seems to be to promote a sort of compromise between those who assign a brief date to man's existence, and those who claim for him a long antiquity.

RAMBLES IN SEARCH OF FLOWERLESS PLANTS. By MARGARET PLUES. (Cottage Gardener Office, Houlston and Wright.)—This handsome and elegantly illustrated volume is a good specimen of a class of works to which the popularization of science is mainly due. It affords just the sort of help that beginners want, and will be very useful in country trips. The subjects range from ferns to mosses, algæ, lichens, and fungi. Miss Plues writes in an interesting, agreeable style; and her directions for the finding of objects and the identification of species are judiciously conveyed. Those who want instructions for collecting a class of objects of great microscopic interest, will find an additional reason for thanking an accomplished lady for her instructive work.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

ROYAL INSTITUTION.—*May* 13.

ON THE MECHANICAL EFFECTS OF GUN COTTON.—In the May number of the INTELLECTUAL OBSERVER, page 302, will be found an account of Professor Abel's lecture at the Royal Institution, "On the Chemical Properties and Preparation of Gun Cotton." Mr. Scott Russell has supplemented this lecture by a second "On its Mechanical Action and General Practical Utility." Gun cotton, as prepared by the Austrian process, is uniform in quality and permanent in action; it possesses the greatest cleanliness in use, not fouling the gun as gunpowder does, and hence possesses great advantages for use with breech-loading arms.

Exploded in the open air it acts differently from gunpowder; if the latter is exploded in one pan of a pair of scales, the arm of the balance is violently depressed. An equal weight of gun cotton,

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on the contrary, can be ignited without moving the pan. In the same manner a bag of gunpowder will blow open the gate of a town which would not be injured by an equal weight of loose or unpacked gun cotton. This appears to arise from the circumstance that gunpowder after explosion leaves about 60 per cent. of solid matter, which acts as a charge and produces the effect of a shot. On the other hand, the products of the explosion of gun cotton are nearly purely gaseous. According to Karolyi these products are—

Carbonic Acid	20·82
Carbonic Oxide	28·95
Nitrogen	12·67
Hydrogen	3·16
Marsh Gas	7·24
Water	25·34
Carbon	1·82

The character of these products appears to account for the circumstance that with gun cotton there is only two-thirds the amount of recoil that is produced by gunpowder in a clean gun; for as sixteen pounds of powder produce by the explosion ten pounds of solid matter, which has to be sent out of the gun at a high velocity, the recoil must be necessarily greater than with gun cotton of equal explosive power, the products of whose combustion is entirely gaseous.

Gun cotton, when employed in artillery service, is found not to heat the gun in the same manner as gunpowder does; this is probably due to the fact that a large quantity of steam is formed during its explosion. This renders so large an amount of heat latent that the gun is not sensibly warmed.

Unlike gunpowder, gun cotton can be wetted and dried repeatedly without injury. This introduces a great element of safety in the manufacture, which is carried on for the most part whilst the gun cotton is damp and consequently inexplosive.

Enclosed in a case or gun the effect of gun cotton is three times greater than that of powder, one pound doing the work of three of powder. Twenty-five pounds of gun cotton placed in a box at the foot of a palisade formed of trees twenty inches in diameter, was found to shatter three of the trees to minute splinters, and to open a wide passage available for military purposes. Four hundred and fifty pounds of gun cotton exploded in the water, twenty feet distant from a vessel of 400 tons, utterly destroyed the ship, some of the fragments being blown upwards of 400 feet high in the air.

Employed for mining purposes it is found that one-twelfth the weight of the coarse mining powder previously used is equally efficient.

In confined places, such as mines and casemates, the absence of sulphurous smoke enables the workmen or soldiers to continue firing any length of time without inconvenience, often a point of great practical importance.

The relative power and properties of gunpowder and gun cotton may be inferred from the following table—

Gunpowder.	Gun Cotton.
100 lbs. occupy 1·8 cubic feet	100 lbs. occupy 4 cubic feet.
55·5 lbs. occupy 1 cubic foot.	25 lbs. occupy 1 cubic foot.

Products of Explosion.

100 lbs. yield on explosion,	100 lbs. yields on explosion,
68 lbs. of solids,	25 lbs. of steam,
32 lbs. of gases,	75 lbs. of permanent gases.

At a lecture delivered at the United Service Institution, Professor Abel combated some of the conclusions arrived at by Mr. Scott Russell, particularly that which attributes the great recoil produced by gunpowder to the projection of the solid residue remaining after the explosion. Professor Abel contended that some of the materials regarded as solid by Mr. Russell, excited a state of vapour at a red heat, particularly the sulphide of potassium, which forms a considerable proportion of the residue. It was also shown that the amount of recoil depends greatly on the mechanical aggregation of the explosive body. Loose gun-cotton exploded on one pan of a pair of scales producing no depression, whereas, if plaited into a cartridge, its effect is well marked.

In the same manner, the recoil produced on a balance by the explosion of gunpowder is much lessened by previously reducing it to a state of fine powder. From these and other considerations, Mr. Abel regarded the theory advanced by Mr. Russell to account for the greater recoil of gunpowder as unsatisfactory.

May 19.

Temperature and Climate of the Moon.—Mr. Nasmyth, who has devoted many years to the diligent observation of Lunar Phenomena, communicated the results of his observations to the members of the Royal Institution, at the Friday evening meeting of this date.

The bulk or solid contents of the moon, as compared with that of the earth, is as 1 to 49. The surface of the moon, as compared with that of the earth, is as 1 to 16. On the supposition that the moon and the earth were formed at the same period, by the condensation of nebulous matter, the rapidity of cooling of the moon would be four times as great as that of the earth, in consequence of its greater surface as compared with its solid contents, hence the moon would have become solid long before the earth, and would offer for our contemplation an object of immense antiquity, the surface of which, from the absence of air and water, would, according to Mr. Nasmyth's hypothesis, have undergone no disintegration or change for millions of ages.

The present condition of the moon's surface, consisting of numerous craters of extinct volcanoes, some, twenty-eight miles in diameter, is in course of description by Mr. Webb in the Intellectual Observer. Some of these volcanic mountains are 28,000 feet high. These are brightly illuminated on one side by the sun; and from the absence of diffused daylight, owing to the want of an atmosphere,

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the further side is in shadow of intense blackness; and from the same cause the sky, as seen from the moon, would appear perfectly dark, the stars being always visible.

The day in the moon is a fortnight in duration, and during this period the temperature on the illuminated side would probably rise to 220° Fahrenheit, or hotter than boiling water. The night would be of equal length, and during this time the heat, from the absence of aqueous vapour and atmosphere, would be radiated freely into space, and the temperature would fall to that of space, viz., to 300° below zero Fahr. The absence of air and water in the moon would render impossible the existence of animal and vegetable life corresponding to that which prevails on our globe.

The use of the moon, as a satellite of the earth, is usually regarded as being that of a luminary, but from its variable action this use must be regarded as secondary. Its value as inducing the tides and currents of the ocean is of greater importance, both as conducing to the sanitary condition of the sea, and as aiding transit in rivers, by the ebb and flow of the tide. At the conclusion of the lecture, Mr. Nasmyth illustrated the formation of the radiating cracks on the moon's surface, by congealing water in a thin glass globe hermetically sealed—when it cracked in lines radiating from a single point—the cracks in the moon being attributed to the contraction of its external hardened crust during the period of its rapid congelation.

June 10.

New Magnetic Experiments.—Professor Tyndall concluded the series of Friday evening discourses, at the Royal Institution, by a Lecture "On a New Magnetic Experiment." After demonstrating the familiar properties of magnetized bodies, he entered into a consideration of the changes of arrangement which the molecules of a piece of soft iron must undergo when it is converted into a temporary induced magnet, by the passage of a current of electricity through the coils of copper wire surrounding it. These molecular changes are proved by the fact that, when a bar of soft iron is magnetized and demagnetized, in succession, by rapidly breaking and remaking the current in the surrounding coil of wire, it is thrown into a state of vibration which produces a sound in the air. This alteration of the molecular arrangement was supposed by Ampère to be attended with a shortening of the bar of soft iron. Mr. Joule, however, has proved that the bar is actually lengthened when it is converted into an induced magnet. The experiment demonstrating this fact was shown in public for the first time.

A bar of soft iron, two feet in length, was firmly secured in an erect position. On its upper extremity was a vertical rod of brass, the lower end of which rested on the top of the iron bar; the upper, tipped with a steel point, pressed against a small plate of agate, near the fulcrum of a horizontal lever. At the distant end of the lever was a very fine wire, which was kept coiled around an axis by the tension of a fine hair spring. This axis turned a small mirror. The action of this exceedingly delicate instrument is easily ex-

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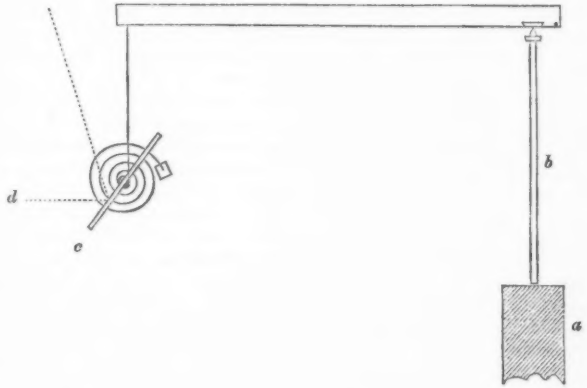
plained. When a current of electricity is sent in a coil around the iron bar, *a*, only the upper end of which is shown in the diagram, it is lengthened to a very minute degree, consequently it presses upwards the brass rod, *b*, and this acting on the lever raises the free end, uncoiling the wire round the axis, and bringing the mirror, *c*, to a position more nearly approaching the perpendicular. This action is so slight that to render it visible to the audience, a horizontal ray of light, shown in the diagram by a dotted line, was reflected from the mirror on to a screen at some distance, when the slightest movement of the mirror was rendered evident by the alteration in the position of the ray, *d*. On magnetizing the iron, the reflected ray was depressed, and on breaking the current the ray returned to its original position.

So exceedingly delicate was the entire apparatus, that the ejection of a few drops of warm water from a pipette upon the iron bar,



produced an immediate depression of the reflected ray. The probable explanation of the lengthening of the iron bar under the influence of the electric coil is, that the particles have a tendency to arrange themselves along the lines of magnetic force, in the direction of the bar. This explanation is supported by a beautiful experiment of Mr. Grove's, which was also shown for the first time at Professor Tyndall's lecture. A cylinder, with glass ends, was filled with a mixture of magnetic oxide of iron and water. This formed a muddy liquid, through which a ray of light could hardly pass. On placing this in the centre of an electric coil, it was found that on making the current the particles, being free to move, arranged themselves in the direction of the axis of the cylinder, and the ray of light passed through with less obstruction. On breaking the current in the coil, the liquid again became muddy and opaque.

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ENTOMOLOGICAL SOCIETY.—*June* 6.

Artificial Modification of Wasps' Nests, and Intelligence in the Honey-Bee.—Mr. Smith, of the British Museum, exhibited a very curious series of boxes. These were from eight to ten inches in height and width, and had either on one or two sides glass, as in cases intended for stuffed animals. Inside of these there were wasps' nests, which were most singular in their arrangement. Some looked like the pillars of a cathedral, others reminded the spectator of limestone caverns, and a third called up decided reminiscences of Stonehenge. These remarkable structures had been formed in each case by one set of wasps. They had been sent for the inspection of the society by Mr. Stone. He found that he could ensure the construction of wasps' nests wherever he chose to make chambers in the earth suitable for the queen wasp to build in. When a nest has been made, he takes it from the earth, puts it in one of the boxes prepared for its reception, and allows the wasps to work in it as long as he wishes, which is generally only a few days. The precise manner in which he determines the plan of their building was not mentioned. It appeared, however, that wires formed the foundation of the architecture, and that the wasps surrounded these with the masticated wood of which they construct their nests. The forms obtained were ingenious and interesting.

Mr. Tegetmeier described an example of intelligence in the honey-bee which has hitherto escaped observation. It is well known that a swarm of bees often take possession of an old tenantless hive filled with comb, having previously visited the hive and cleaned away the refuse materials and damaged portions. On placing a frame-hive, in which old combs had been artificially attached, near a stock that was expected to throw off a swarm, it was seen that the bees visited it, and that numerous scales of newly-secreted wax were found on the floor-board. This led to an attentive examination of the combs, and it was discovered that new white wax had been secreted in the empty hive, and that this had been employed in repairing the combs, particularly in cementing them more securely to the top of the hive, their attachment being strengthened at that point where the greatest weight would have to be sustained when the combs should be filled with young brood, honey, and pollen. It appears an extraordinary instance of foresight and intelligence, as distinct from unreasoning instinct, that the bees, when proposing to send out a swarm to tenant a new residence, should not only clean the hive, but send a relay of worker-bees to cluster and secrete wax in order to strengthen the combs at that part where the greatest weight will have to be supported.

GEOLOGICAL SOCIETY.—*June* 8.

On the Geological Structure of the Malvern Hills and Adjacent District. By Dr. Harvey B. Holl.—The object of this com-

munication was to discuss the structure and origin of the crystalline rocks of the Malvern Hills, to give the results of an examination of the superposed Palæozoic strata, and to state the chronological relationship of the several events in their geological history.

It was concluded that the rocks hitherto treated of as syenite, and supposed to form the axis of the range of hill, are in reality of metamorphic origin, consisting of gneiss (both micaceous and hornblendic), mica-schist, hornblende-schist, etc., all invaded by veins of granite and trap-rocks. It was then shown that the Holly-bush Sandstone is the equivalent of the Middle Lingula-flags, and that the overlying black shales correspond with the Upper Lingula-beds, the whole being overlaid, as in Wales, by Dictyonema-shales. These rocks, on the east of the Herefordshire Beacon, are altered by trap-dykes, which were shown to be of later date than those traversing the crystalline rocks before alluded to. Allusion was next made to the Upper Llandovery strata, which overlie unconformably the Primordial rocks just noticed; after which the several faults in the district were described in detail.

Dr. Holl concluded with some remarks on the general relations of the rocks of the Malvern Hills with those of the surrounding districts, describing the successive physical changes supposed to have been consequent upon their deposition and their subsequent elevations and depressions.

Specimens of the new mineral termed Langite, a basic sulphate of copper, were exhibited by Professor Maskelyne.

ROYAL SOCIETY.—*June* 9.

Human Remains in the Cavern of Bruniquel.—Professor Owen described his investigations in the cavern at Bruniquel, in which human remains occur, with those of extinct and other animals, both being associated with bone and flint implements. Professor Owen argued that these human and extinct animal remains were contemporaneous, as shown by their relative position in this cavern, and by the similarity in their chemical composition.

The remains found in this cavern were those of numerous individuals, the skulls corresponding more closely to the Celtic type than to any other known form. As, in most primitive races, the digestibility of the food appeared to be but little aided by the process of cooking, as the molars were worn down to the stumps far beyond the enamel, exposing the osteo dentine, which, however, did not show any signs of decay.

Microscopic Soirée at Apothecaries' Hall.—The Master and Wardens of the Apothecaries' Company, gave a very successful and numerously attended scientific entertainment on the 31st of May. All the principal makers of microscopes were well represented on

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the occasion, and the collection of objects was very good. The principal novelties were an opthalmoscope, by which the vessels in the interior of a rabbit's eye were distinctly seen; a new aneroid, by Mr. Browning; and a beautiful diffraction apparatus, by Messrs. Horne and Thornthwaite. The two last deserve a much longer notice than we can give them in this place. The aneroid, which we hope to describe fully another time, is a stationary instrument of extreme delicacy, enabling small oscillations to be read off on a large scale, and admirably adapted for noting the exact progress of atmospheric waves during a storm.

Mr. De la Rue's Astronomical Soirée.—On Saturday, June 4, Mr. Warren De la Rue, the President of the Royal Astronomical Society, held a reception at Willis's Rooms, which was attended by a very numerous and distinguished company. The arrangements were made with great liberality and good taste, and a variety of important and interesting objects were brought together. Mr. Nasmyth exhibited some large and wonderful drawings of lunar craters; Earl Rosse sent sketches of nebulæ, and the walls were adorned with some singularly beautiful landscapes of Turner. Steinheil sent a Gauss object-glass upon the pattern mentioned in a former number of this journal, and Merz sent a 10-inch object glass; Cooke and Sons showed some fine telescopes, and a new arrangement for obtaining a dark field illumination; Messrs. Troughton and Sons exhibited instruments for the Indian Survey, among which was an enormous theodolite in aluminium bronze. Mr. Browning's new aneroid attracted great attention, and he also exhibited some splendid prisms, one on a large scale, being constructed of quartz, and made for Mr. Gassiott, who was fortunate in securing a crystal of rare dimensions and unusual freedom from optical defects. Messrs. Horne and Thornthwaite, in addition to their diffraction apparatus, for which Mr. Bridges designed the figures, exhibited a new form of polariscope capable of showing a much wider range of effects than the usual patterns allow to be seen, and in a manner that commanded universal admiration. Mr. De la Rue exhibited a complete collection of his astronomical photographs. Messrs. Powell and Lealand, Ross, and Smith and Beck brought their microscopes, the latter showing the pupa of the flea and the Acarus Crossii. There were also specimens of the long focus telescopes that preceded the achromatics, and numerous instruments of the most modern designs. Mr. Ladd exhibited some fine effects with vacuum tubes.

NOTES AND MEMORANDA.

THE CONSERVATION OF POLLEN.—M. Belhomme details to the French Academy numerous experiments on the "persistence of the fecundating power of pollen." He gathers anthers in dry weather, at the moment when dehiscence begins, seals them up in bottles, and places the bottles in a dark, dry place, in which the temperature will not exceed 6° or 8° C. The pollen grains that have been successfully preserved remain slightly moist, those which have dried so that they do not adhere slightly to the skin, and those which fall like dust, are spoilt. He has proved that the pollen of the lily tribe can preserve its fertility for five or six years, that of the musaceæ he has preserved for six years, of the borage tribe one year, and of the potato tribe two years, of cactuses three years, and of the rose and bean tribes two years.

DEVIATION OF COMETS' TAILS.—M. Valz shows that the tails of Comets iv. and v., 1863, deviated from the planes of their orbits. He adverts to two other comets in which the same fact was ascertained.—*Comptes Rendus*, No. 19, 1864.

USE OF ELECTRICITY IN BRIGHT'S DISEASE.—M. Namias communicates to the French Academy a case in which the obstacle to the separation of urea from the blood was removed by the application of galvanism to the loins of the patient for half an hour. Twelve of Daniell's cells were employed, and the quantity of urine and urea much increased. More albumen was also secreted, but M. Namias states that this was of small consequence compared with the benefit resulting from a greater elimination of urea.

ALVAN CLARK ON THE SUN AND STARS.—Mr. Alvan Clark views the solar image in a dark chamber. The sunlight is admitted through a vertical aperture, received by a prism, and reflected horizontally on to a pleno-convex lens. The solar image thus obtained is viewed from a distance of 230 feet, and its diameter reduced 93,840 times, being then scarcely equal in illuminating power to α Lyræ (Vega). Making allowance for loss of light through the apparatus employed, Mr. Clark considers that if the sun were removed 103,224 times his actual distance from us, he would not give us more light than the star in question, and this distance, he observes, is not half the presumed distance of the nearest fixed star. He also alleges reasons for supposing that our sun may be a small star in comparison with some of the millions of other stars that inhabit space.

STRUVE ON THE COMPANION OF SIRIUS.—In the *Monthly Notices* will be found a paper by M. Struve detailing his observations on the satellite of Sirius. The average of good observations in 1863 gave 10″·14 as the distance, and 80°·5 as the position; while the average of good observations in 1864 yielded 10″·92 distance 74°·8 position. According to which the annual change of distance is 0″·77, and of position °5·7.—This nearly coincides with Mr. Safford's calculations, based on the supposition that there is no physical connection between the two stars. M. Struve does not, however, consider this view established, and suspends his judgment till next year.

HABITS OF WASPS.—Professor R. L. Edgworth has a paper in the *Annals of Natural History* on Irish wasps, in which he denies the statement of Reaumur, repeated by Kirby and Spence, that at the first cold of winter, wasps kill their young. He says possibly the grubs, in some rare cases, may have been killed by an early frost, and it may have been thought they were intentionally slain. He states that the wasps are hatched before cold weather usually begins. The love they display for their young, and the place of their birth, he characterizes as very remarkable, and he adds that they soon become familiarized with any animal or man. In one instance he tells us that a field-mouse and a nest of wasps shared a common hole, without injury to the former. The presence of other wasps does not appear to disturb their equanimity, and in one case he planted four colonies together, and they all flourished. He also bisected two nests and put the halves of dissimilar nests together. The wasps surrounded both halves with a common shell, and made one nest of it.

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Action of Tobacco on the Pulse.—M. Decaisne states, in *Comptes Rendus*, that in the course of three years he has met with twenty-one cases of intermittent pulse occurring among eighty-eight incorrigible smokers, and independent of an organic disease of the heart. He calls the affection thus induced by the abuse of tobacco, "Narcotism of the heart."

Bolide of May 14.—At Nérac, on this date, a very luminous bolide was seen in the evening, and four or five minutes after its passage a powerful detonation was heard, accompanied by a rumbling like thunder. At St. Clar the light was so brilliant at 8h. 13m. as to give rise to the idea that the village was in flames, and the meteor looked nearly as big as the full moon. It left a train behind it, which gradually disappeared, and in the course of ten minutes a noise was heard like the discharge of a cannon. Letters from Astaffont, Sauzon, and Blois reached M. Le Verrier with analogous particulars. The Curé of la Magdeleine describes the meteor as opening like a bouquet of fireworks. Superstitious folks thought the world was coming to an end. M. Daubrée observes that the interval between the appearance of the meteor and the noise was two minutes at St. Clar (Ger), three to four at Agen, and at Astaffont (Lot et Garonne) four minutes. From these data he concludes that the explosion took place at a great elevation and in a highly rarified atmosphere. M. Brongniart made observations at Fisors (Eure), from which he estimated the meteor's height when the explosion occurred at about 30,000 metres. He states that at the close of the phenomena there was a fall of stones, several of which were picked up. M. Flammarion, writing in *Cosmos*, states that this meteorite contained carbide of iron, and belonged to a rare type. Numerous letters on this subject will be found in *Comptes Rendus*, No. 1, 1864; and also in No. 21, in which M. Laussedat details his efforts to compute the size and trajectory of the meteor. He finds many of the reports irreconcilable, but by combining an observation made at Nérac with another at Tombebœuf, near Miramont, he considers the bolide must have been near the meridian of Nérac, and about 100 kilometres high.

The Anacharis in Flower.—It is commonly, though not correctly, said that the Anacharis alsinastrum does not flower in this country. It will, therefore, interest our readers to learn that Mr. Mumbray, of Richmond, has recently obtained specimens in flower from the Hampstead ponds. The flower, which is borne at the end of a thread-like stalk, is an elegant object when viewed with an inch power. The ponds on the Lower Heath contain abundance of specimens. The Anacharis belongs to the Hydrocharis family, in which the flowers are unisexual, and it is the male flowers that have not been seen in England.

Cure of Febrile Cephalalgia.—M. Guyon communicates to the French Academy cases in which the acute head pains in fever have ceased on the application of pressure to the temporal arteries. A steel band, passing half round the head and furnished with little cushions, he finds a convenient mode of making the application.

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